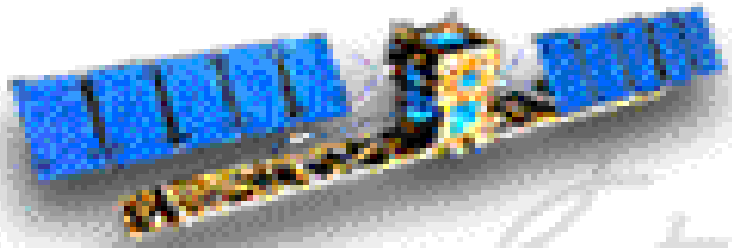


ADWR's Land Subsidence Monitoring Program

Interferometric Synthetic Aperture Radar (InSAR)

Brian D. Conway

Hydrology Division

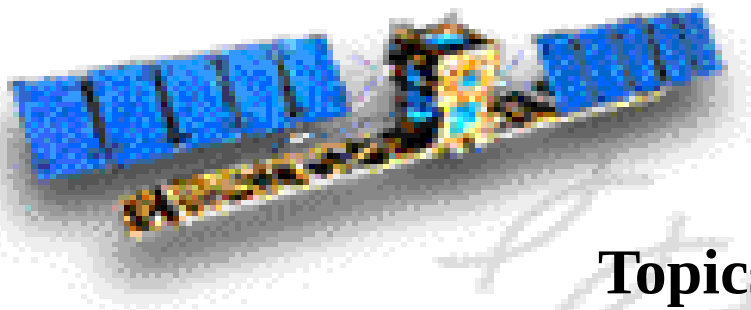
Geophysics/Surveying Unit

ARIZONA DEPARTMENT OF WATER RESOURCES

Image courtesy of the Canadian Center for Remote Sensing


SUBSIDENCE
AREA

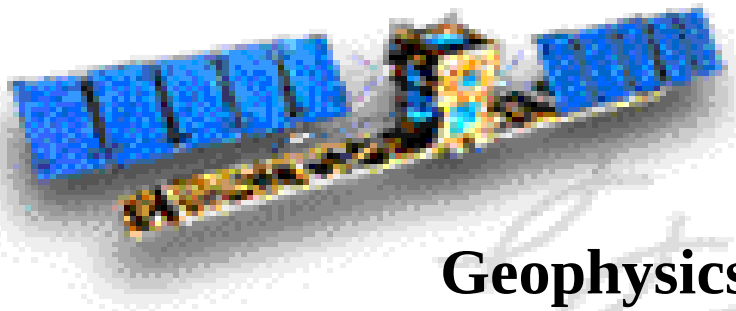

NOTICE
EARTH FISSURE
POSSIBLE ROAD HAZARD
USE CAUTION
STOP



Topics Discussed

1. What is Land Subsidence (Land Subsidence 101)
2. Brief history of ADWR's land subsidence monitoring program.
3. Discuss SAR and InSAR technology.
4. Discuss the applications of InSAR for land subsidence monitoring and other projects.

Geophysics/Surveying Unit

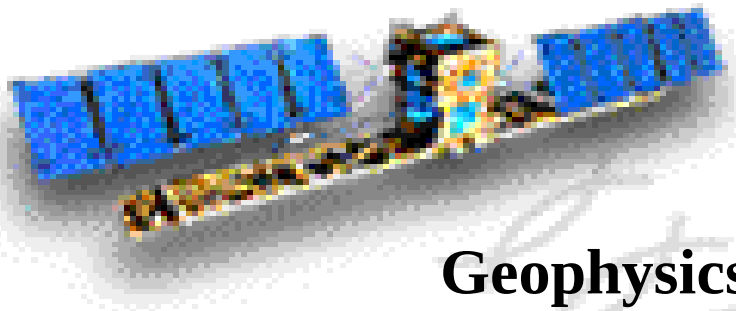


Geophysics/Surveying Unit

- **Gravity surveying for aquifer storage monitoring.**

Geophysics/Surveying Unit

- **Gravity surveying**

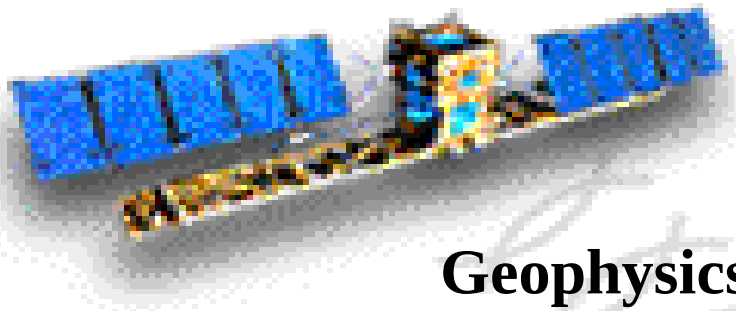


Geophysics/Surveying Unit

- **Gravity surveying for aquifer storage monitoring.**
- **Gravity surveying for depth-to-bedrock modeling and water-in-storage estimates.**

Geophysics/Surveying Unit

- **Gravity surveyin**
- **Gravity surveyin estimates.**



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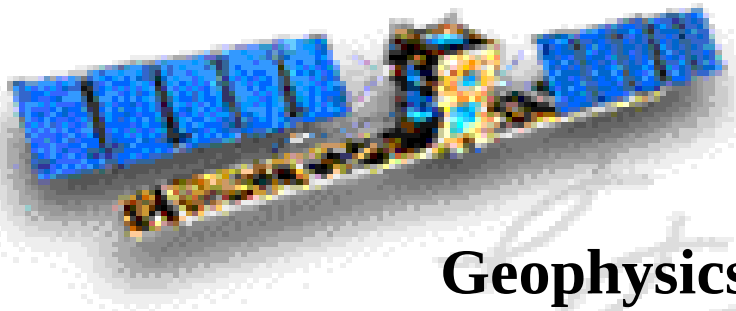
- **Gravity surveying for depth-to-bedrock modeling and water-in-storage estimates.**
- **Gravity surveying to obtain hydraulic parameters for use in groundwater models.**



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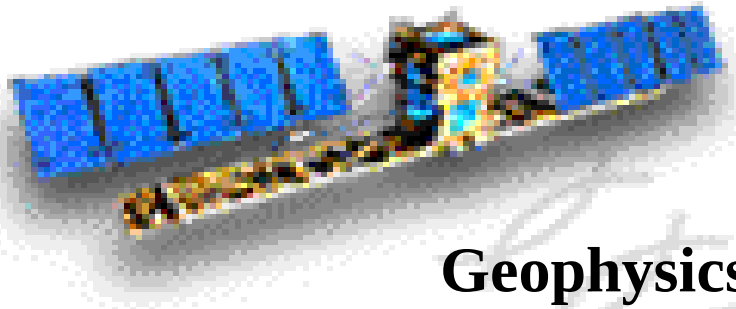
- **Collect, process, and analyze InSAR data for land subsidence monitoring.**



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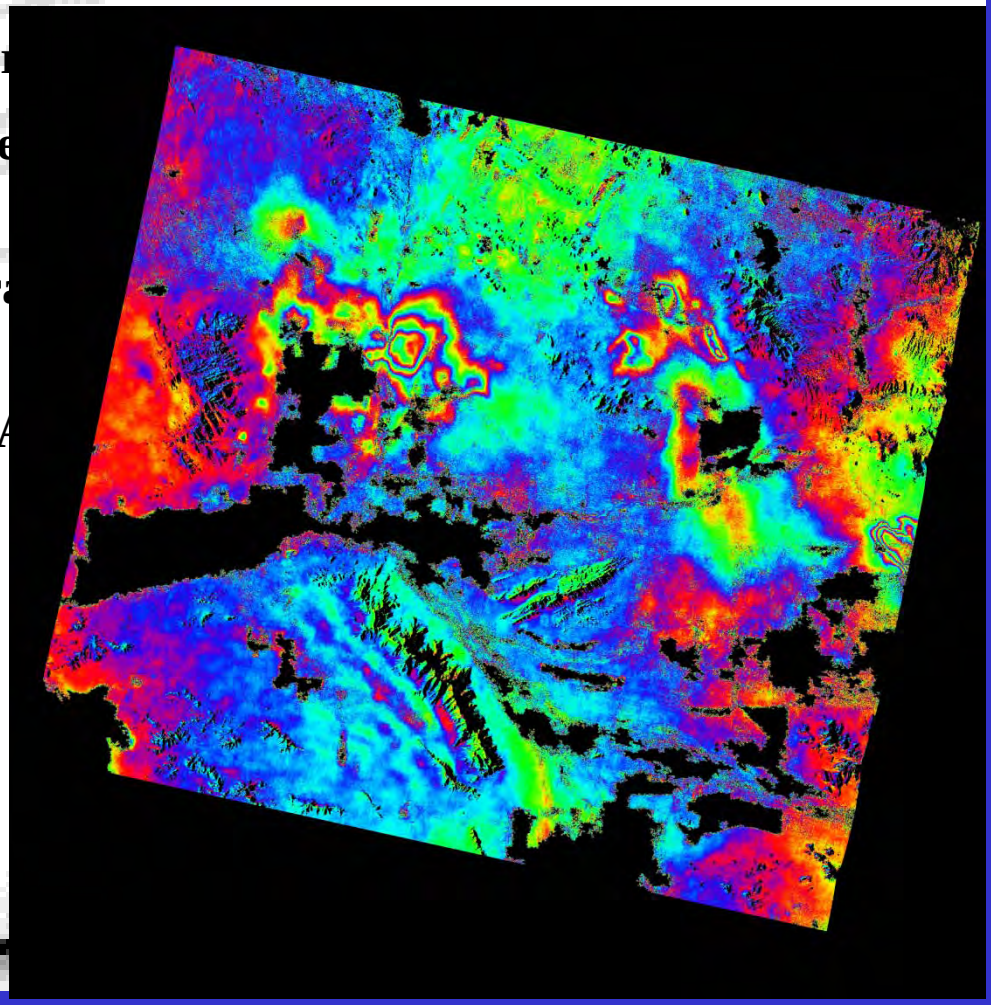
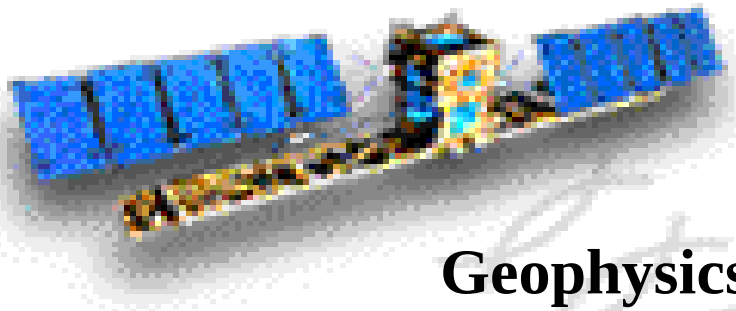




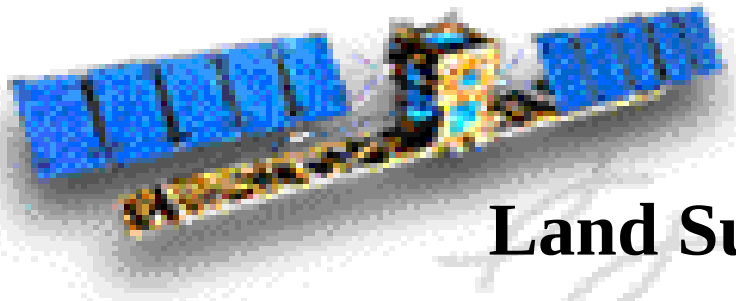
Geophysics/Surveying Unit

- **Gravity surveying for aquifer storage monitoring.**
- **Gravity surveying for depth-to-bedrock modeling and water-in-storage estimates.**
- **Gravity surveying to obtain hydrologic parameters for use in groundwater models.**
- **Collect, process, and analyze InSAR data for land subsidence monitoring.**
- **GPS surveying to support land subsidence monitoring, aquifer storage monitoring, WQARF program, transducer program and other ADWR programs.**

Geophysics/Surveying Unit

onitoring.

modeling and water-in-storage

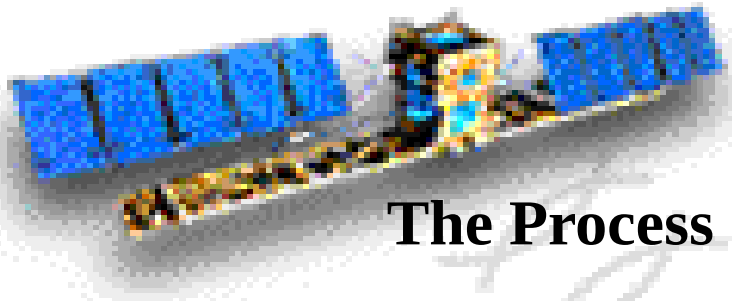


Land Subsidence 101

- Land subsidence is the lowering of the land-surface from changes that take place underground.

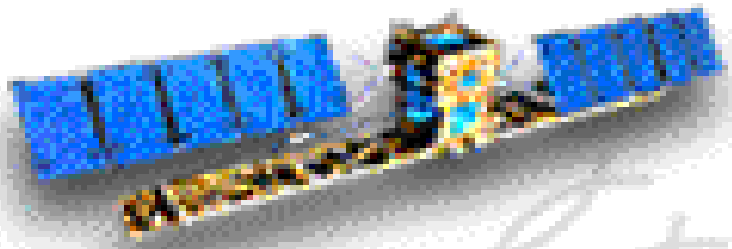
Human activities that cause land subsidence:

- The Pumping of water, oil and gas from reservoirs beneath the ground
- Dissolution of limestone aquifer (Sinkholes)
- Collapse of underground mines
- Drainage of organic soils and initial wetting of dry soils (hydrocompaction)



The Process of Land Subsidence

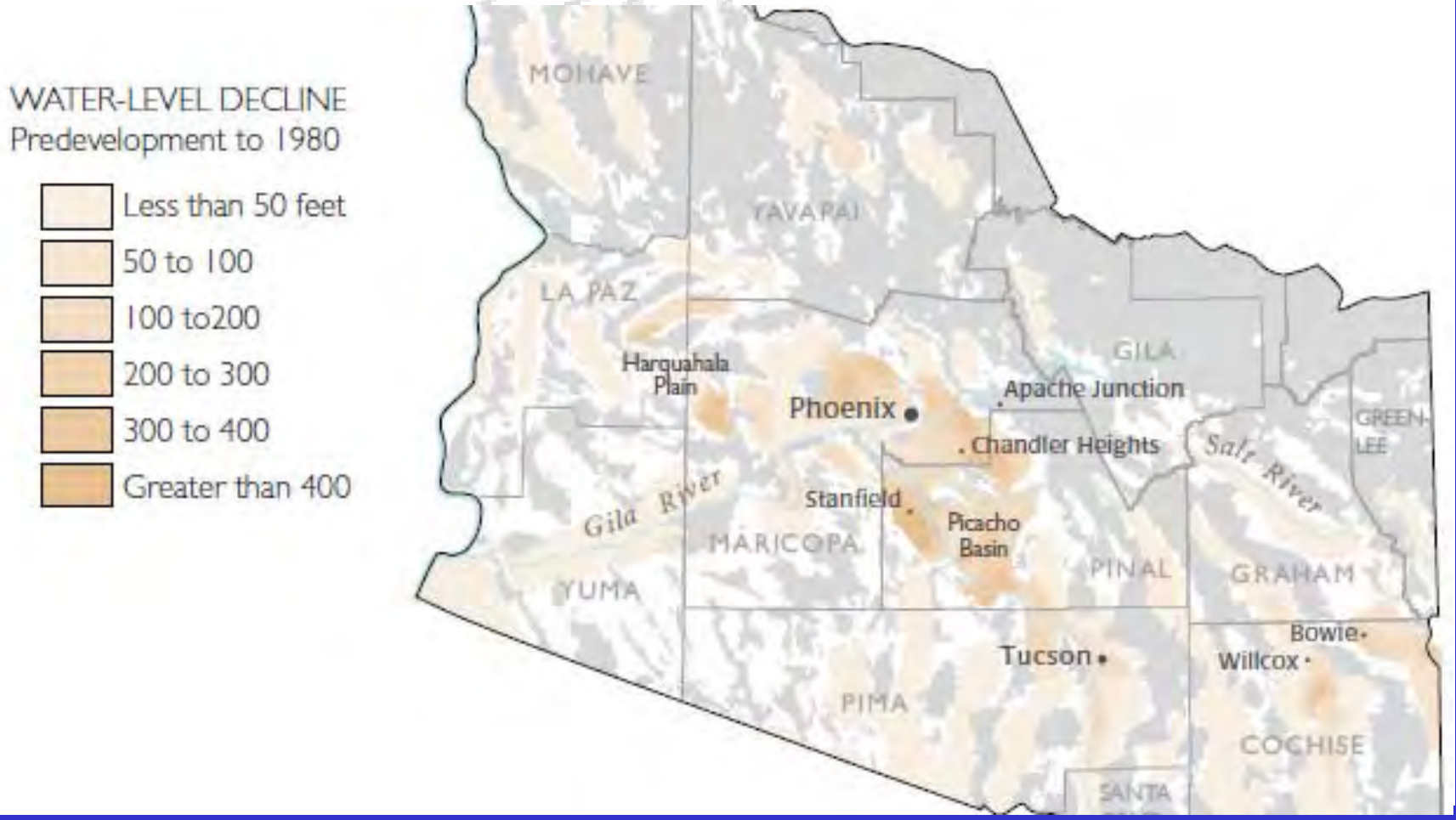
- Water is removed from pore spaces between grains of sand and gravel.
- Smaller grain material (silt and clay) are found in these pore spaces
- As the water is removed from the pore spaces, the water pressure is lowered, resulting in the drainage of water from the clay and silt.
- The reduced water pressure creates a loss of support for the clay and/or silt materials, resulting in compression and compaction.
- Subsidence Has Occurred.

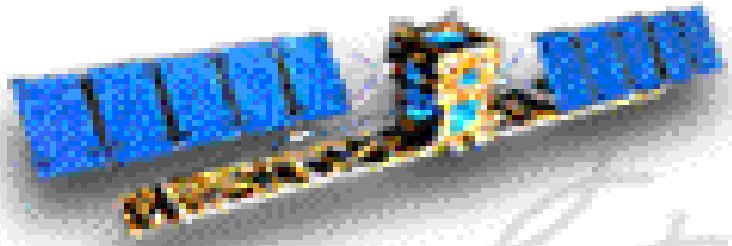


Subsidence within Arizona is due to the historical groundwater withdrawal (pumping) of aquifer systems.

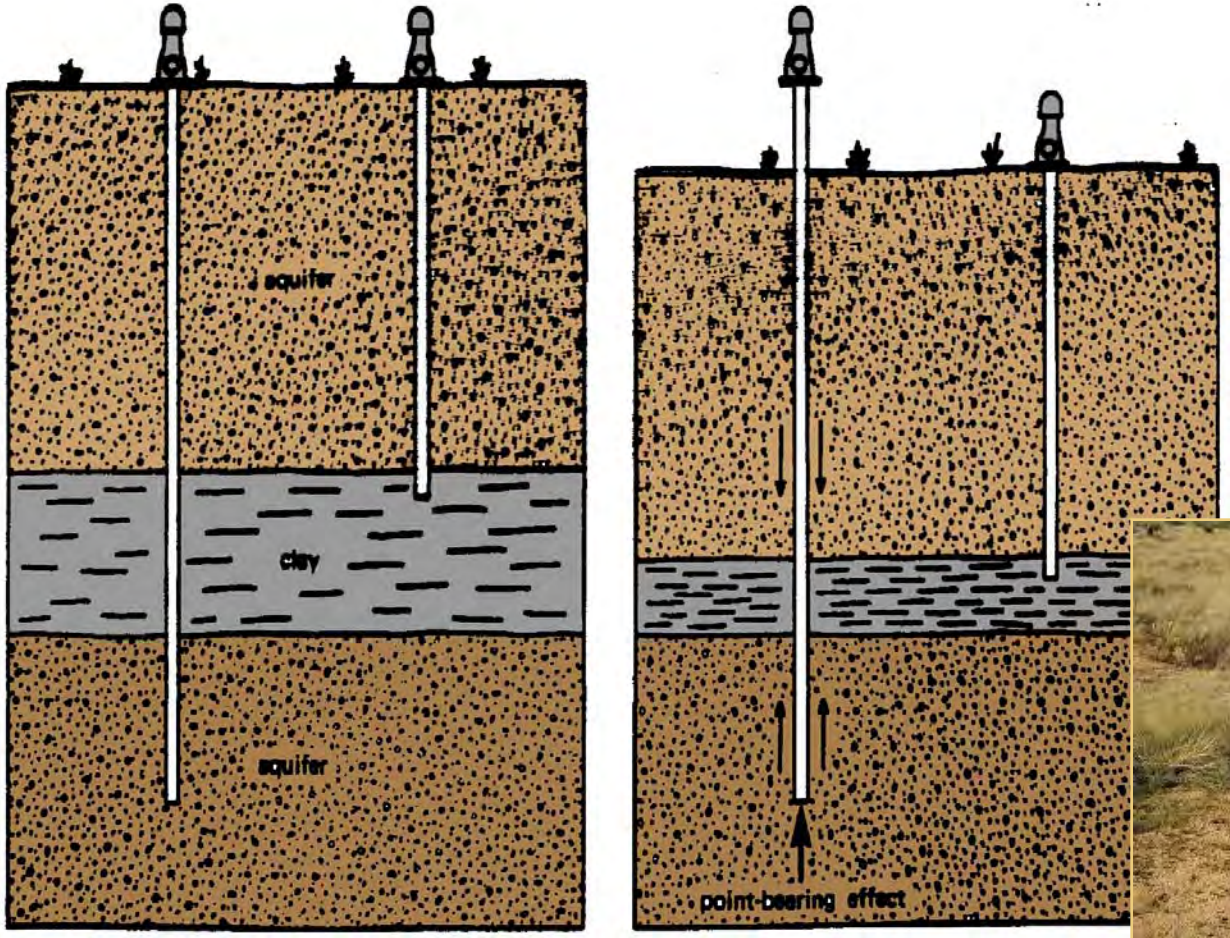
- Groundwater levels have dropped as much as 400 feet in areas around Arizona since the 1900's.
- The geologic composition of the basins of Arizona consists of gravel, sand, clay, salt, and silt.

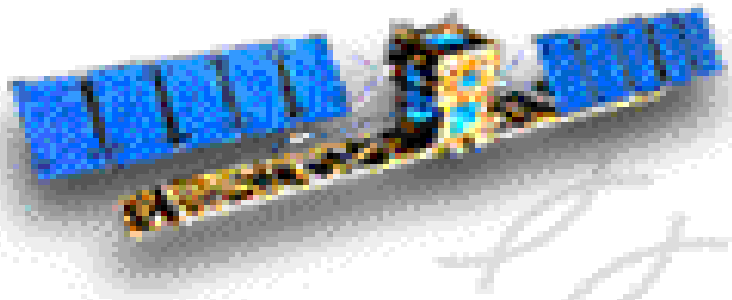
Change in Groundwater Levels in Central and Southern Arizona Between 1900 and 1980





Land Subsidence and Groundwater Withdrawal

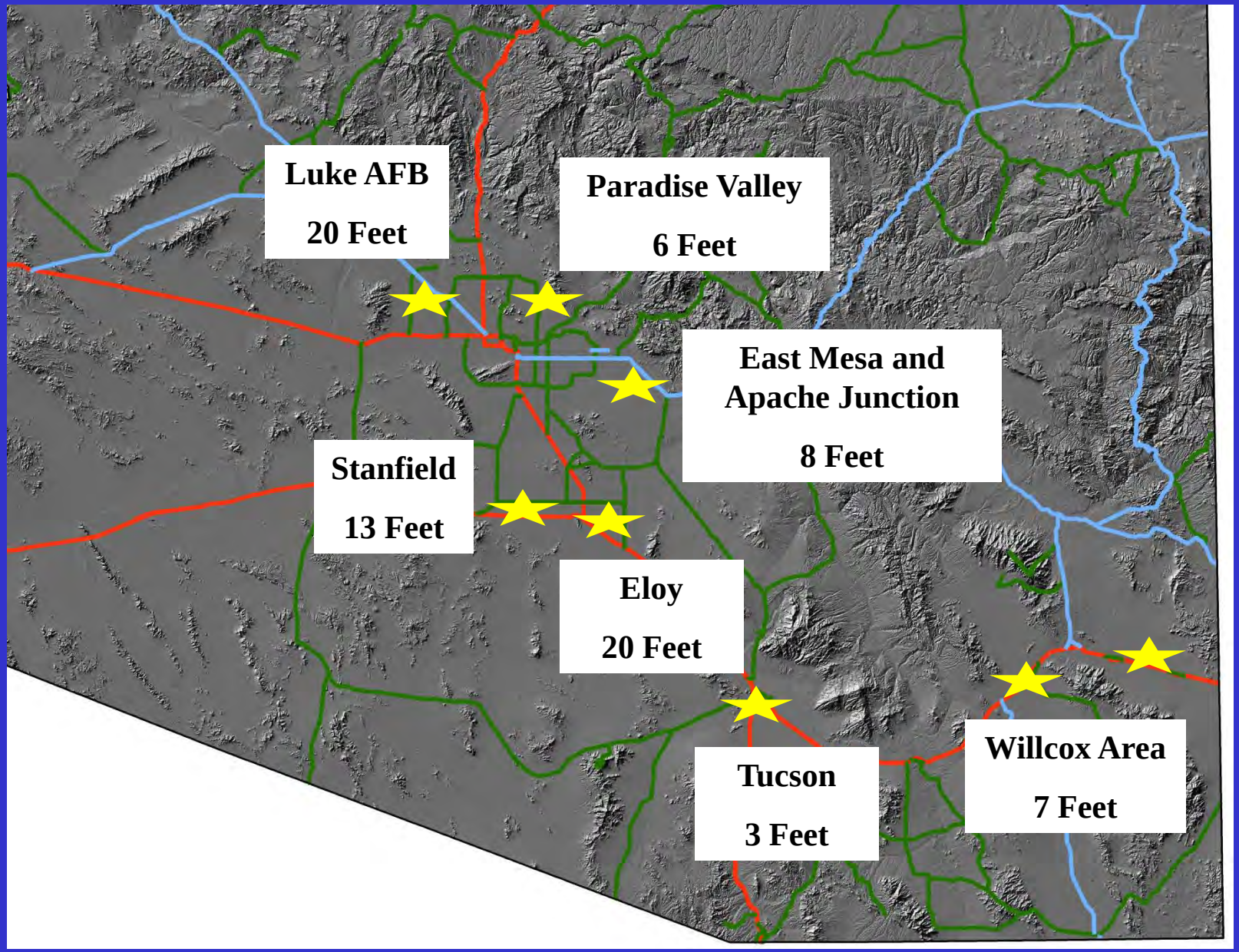




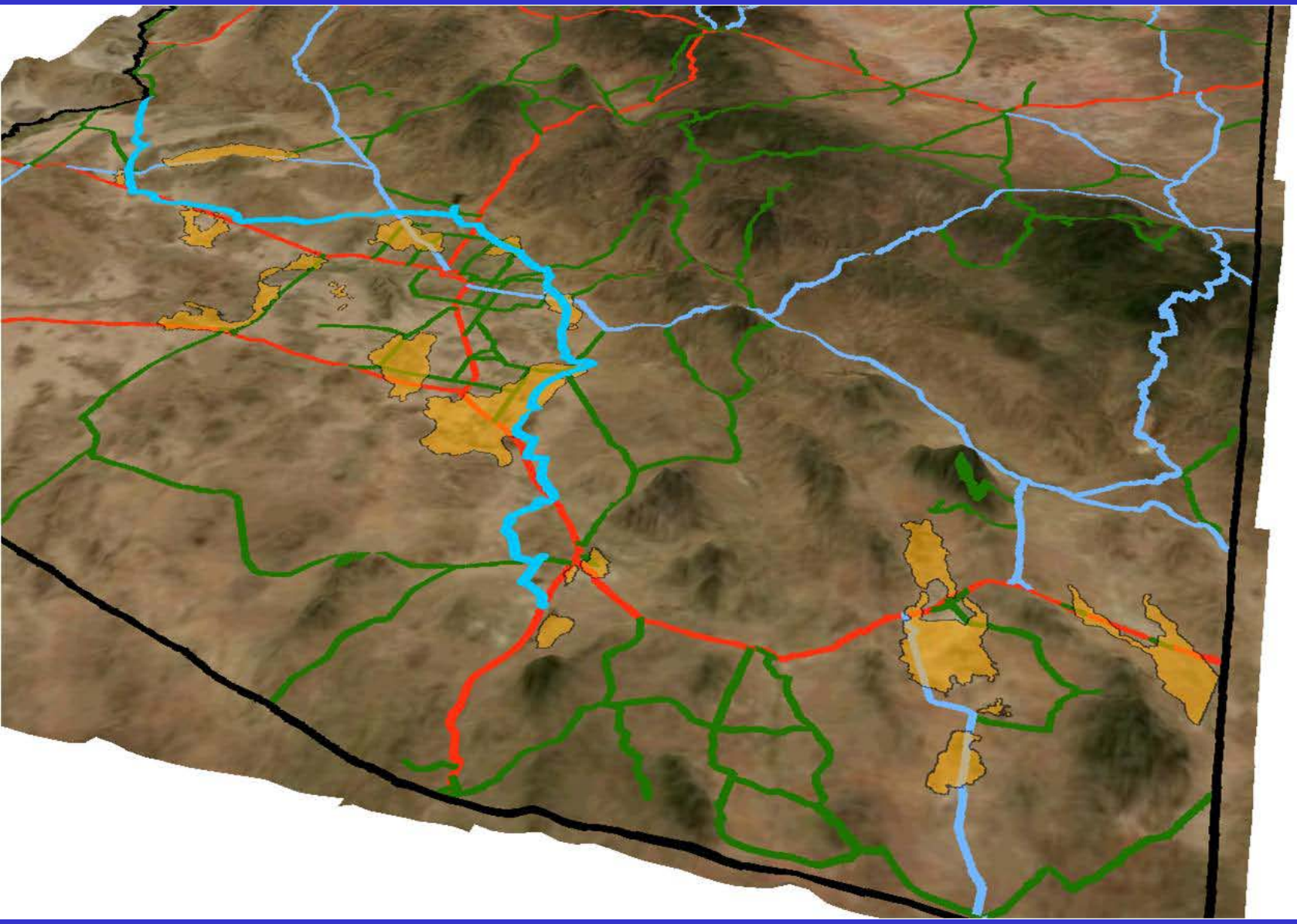
Where Has Subsidence Occurred?

And How Much?

Where and How Much?

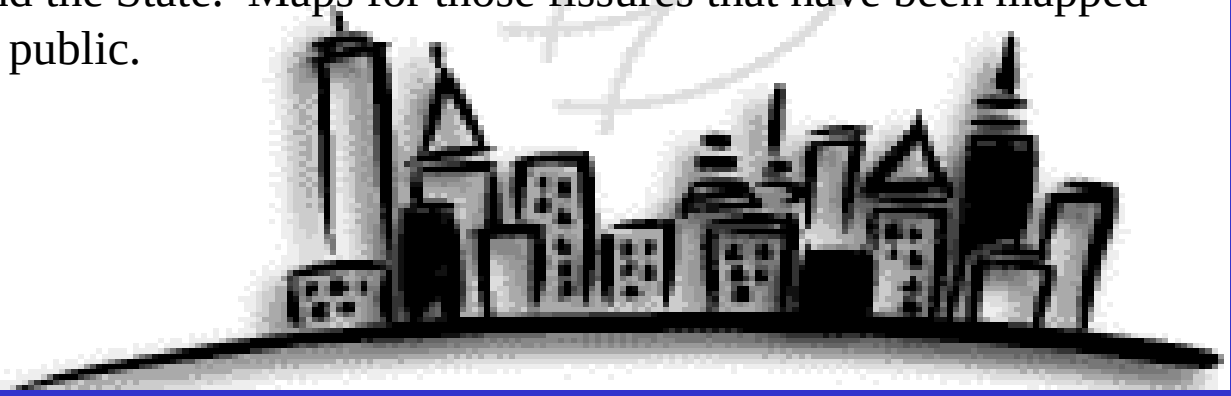


Aerial Flight of Land Subsidence Areas throughout Central and Southern Arizona

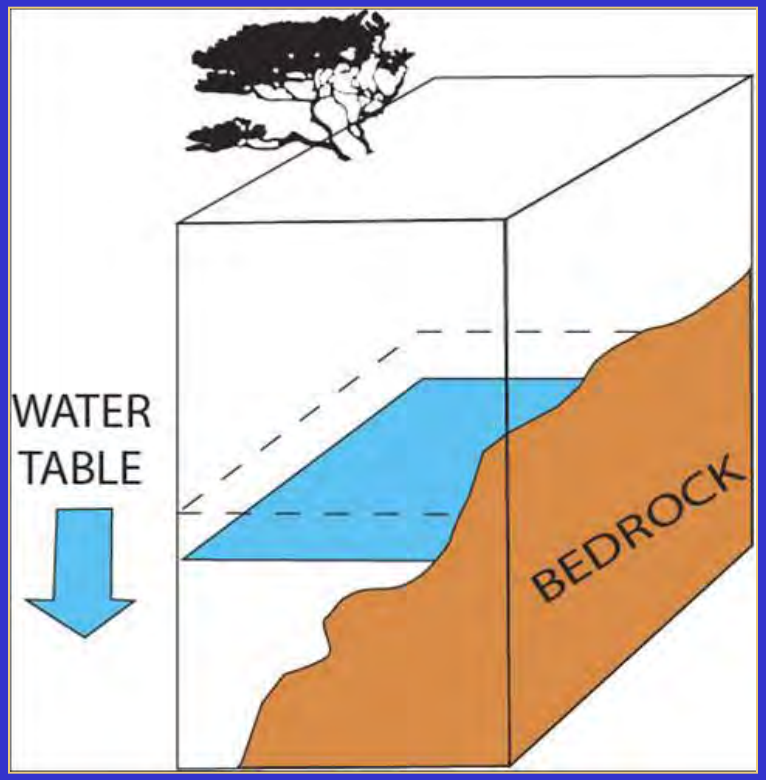


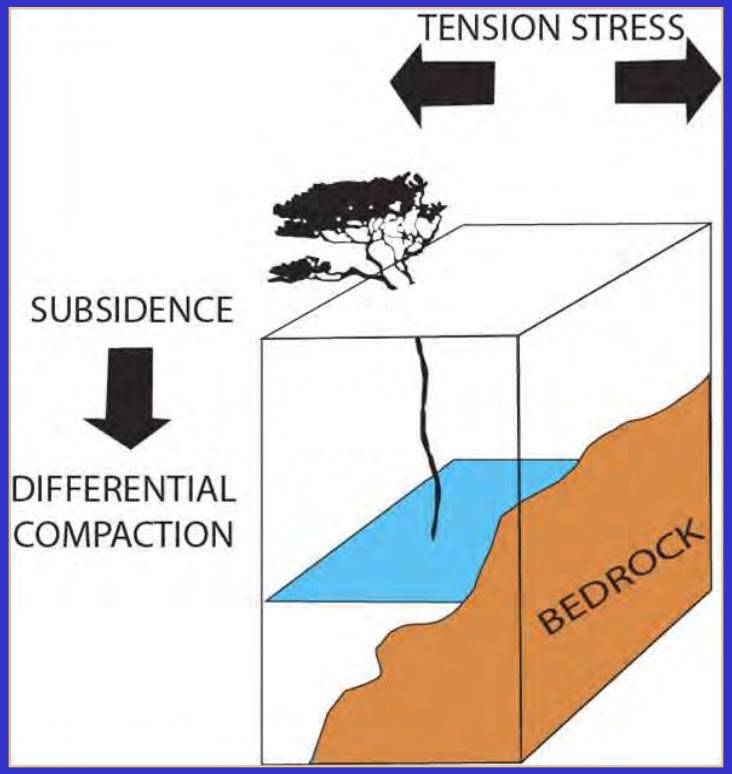
Earth Fissure Development

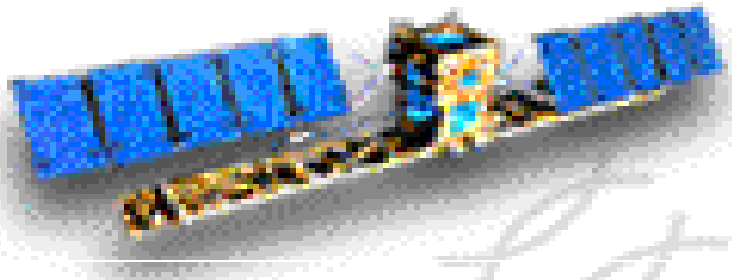
- Earth Fissures are the result of subsidence.
- Earth Fissures develop near bedrock and areas that transition between different types of geological material.
- Earth Fissures start out as hairline cracks but can open up at the surface with the interaction of surface water flow.
- Limited knowledge on the science of earth fissures.
- Arizona Geological Survey is in the process of identifying and mapping all the earth fissures around the State. Maps for those fissures that have been mapped are available to the public.



Earth Fissure Development

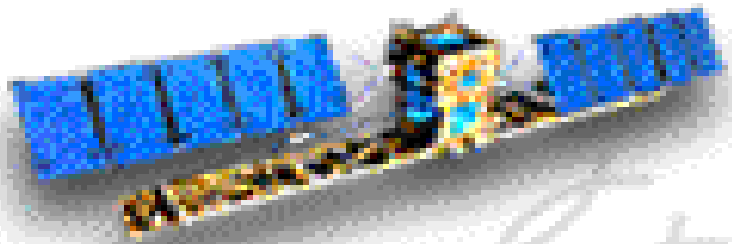






Problems Caused by Land Subsidence and Earth Fissures

- Damage to infrastructure (CAP canal, highways, sewer and water lines) and private property.
- Expenses incurred to mitigate land subsidence and earth fissures.
- Changing the natural slope of the floodplain (areas that did not flood now flood).
- Severe or even fatal injuries to people and livestock.
- Loss of groundwater storage and possible change to the hydraulic properties of the aquifer.

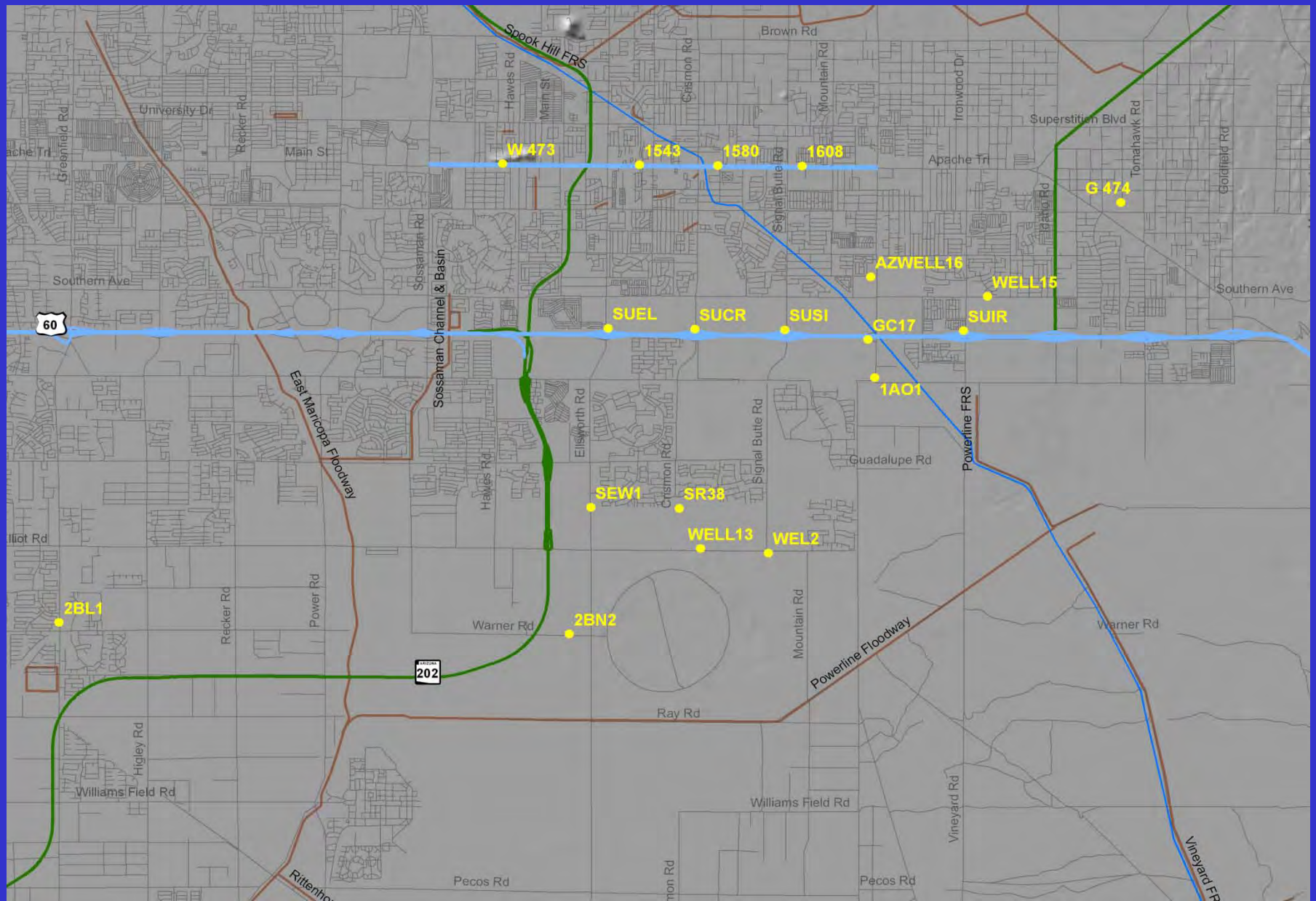


ADWR'S LAND SUBSIDENCE MONITORING PROGRAM

1. 1997 Directorate level decision to begin land subsidence monitoring program .
2. Began work in 1998 with annual static GPS surveys
3. Quickly migrated to emphasis on SAR/InSAR, with GPS support in 2001.
4. Center For Space Research grant (ADWR funded) to collect InSAR data.
5. Awarded $1.3 million NASA grant in 2002 to further develop ADWR's InSAR program for the next three years.
6. By 2008, ADWR identified and monitored more than 16 land subsidence features around Central and Southern Arizona.

Monitoring Land Subsidence With Static GPS Surveys

Hawk Rock GPS Network in East Mesa/Apache Junction Area, Maricopa/Pinal Counties



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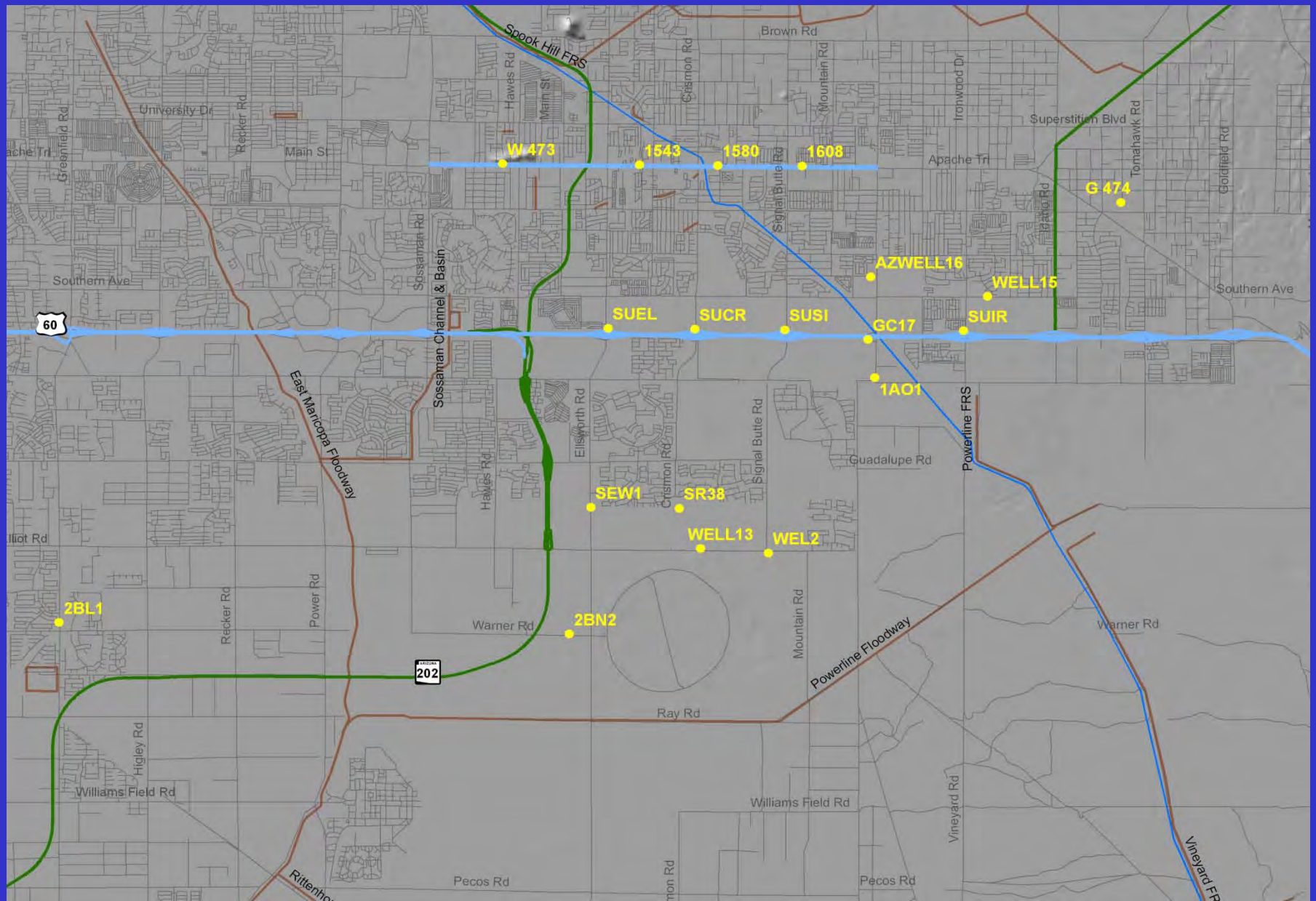

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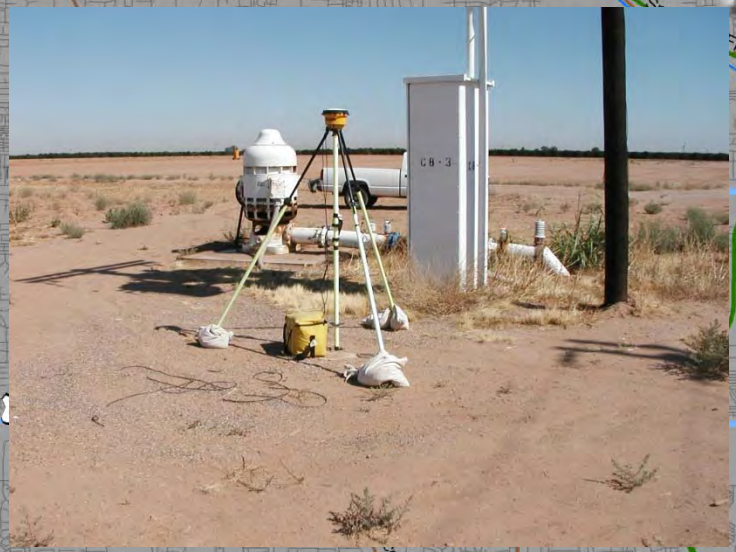
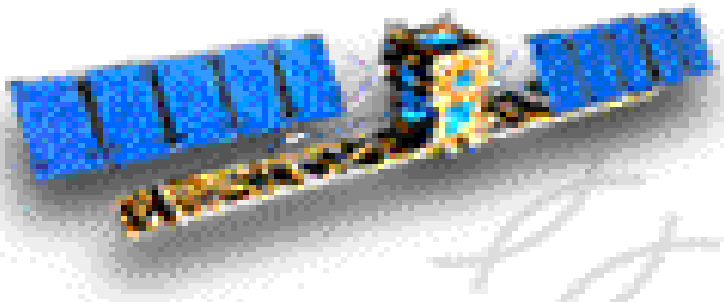
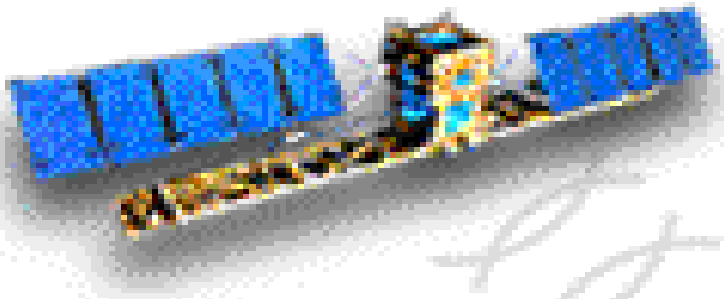


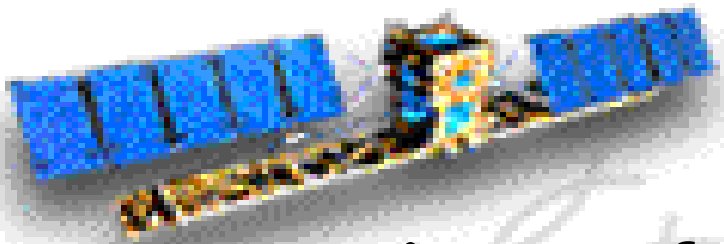


ADWR InSAR Program

Used For Land Subsidence Monitoring

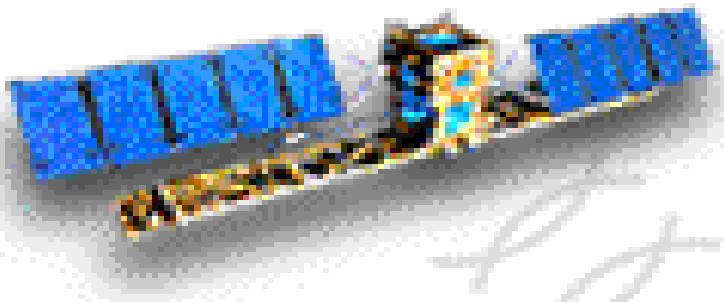


Differential SAR Interferometry (DiffSAR)



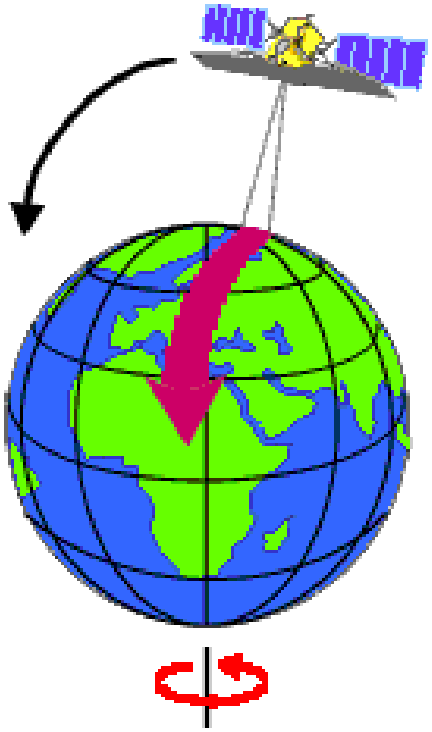
Measuring Surface Motion from Space

- Surface motion can arise from a variety of phenomena
  - Earthquakes
  - Underground excavation
  - Groundwater withdrawal
  - Hard target motion
- “Conventional” techniques have a variety of drawbacks
  - Only discreet spatial measurements
  - Expensive
- Civil space borne SAR technology has shown excellent success in producing ground motion measurements with differential interferometry (DiffSAR)



SAR SATELLITE CHARACTERISTICS

- Active sensors (day/night/clouds)
- Near Circular, Polar Orbit
- Period approx. 100 minutes (4.5 miles/sec)
- Approx. 800 km altitude
- Approx. 14 orbits/day
- Repeat cycle 8-46 days
- Need to be tasked



Relevant Satellite SAR Missions

Satellite	Dates	Sponsor	Band	Repeat Orbit
ERS-1	1991-2000	Europe	C	35 Days
JERS-1	1992-1998	Japan	L	44 Days
ERS-2	1995-	Europe	C	35 Days
Radarsat-1	1995-2007	Canada	C	24 Days
Envisat	2002-2010	Europe	C	35 Days
ALOS	2004-	Japan	L	46 Days
TerraSAR-X	2005-	Germany/Astrium	X	10 Days
Radarsat-2	2007-	Canada	C	24 Days
Sentinel-1	2011	Europe	C	12 Days
DESDynI	2018?	USA	L	8 Days

- **Cannot perform InSAR across different satellite platforms except for ERS 1/2.**
- **Shorter repeat orbit periods results in less overlap between adjacent tracks.**
- **L-band penetrates vegetation, C/X-band are unable to penetrate all vegetation.**
- **TerraSAR-X provides higher resolution imagery as compared with other missions.**

****** User must have strategy to transition from one platform to the next ******

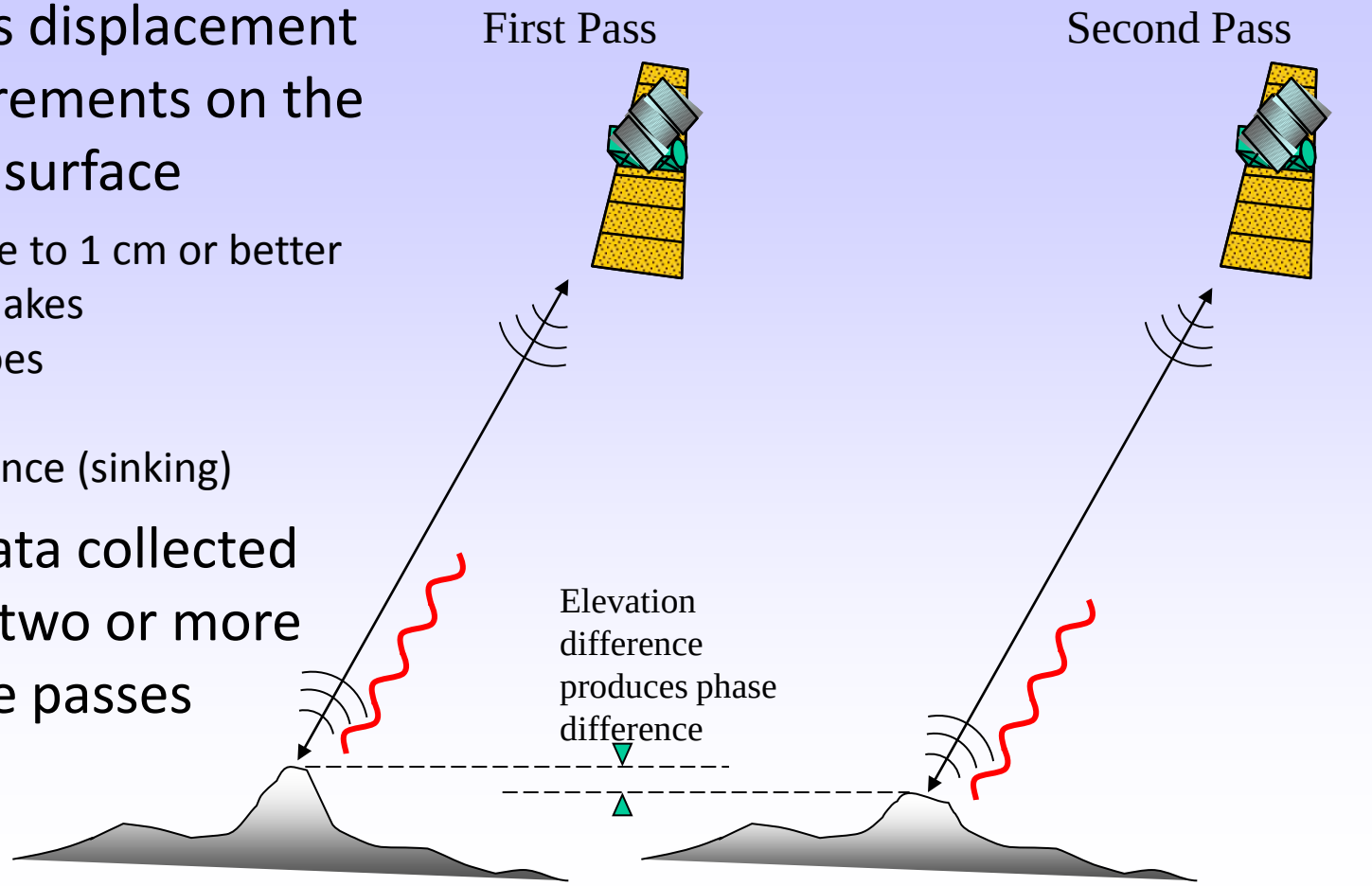
- **Continue acquiring data from older platform while acquiring data from newer mission.**
- **Careful selection of imaging modes.**

Synthetic Aperture Radar Interferometry (DiffSAR)

Enables displacement measurements on the Earth's surface

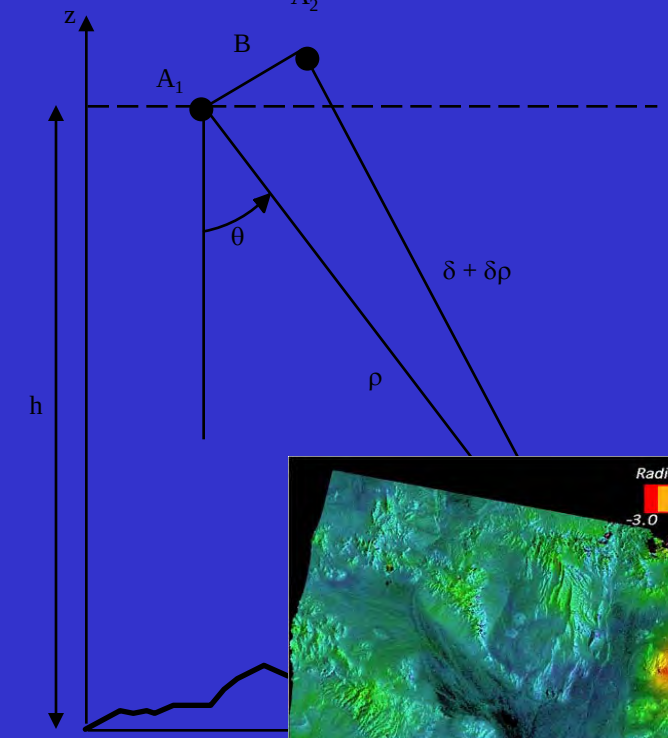
- Accurate to 1 cm or better
- Earthquakes
- Volcanoes
- Ice
- Subsidence (sinking)

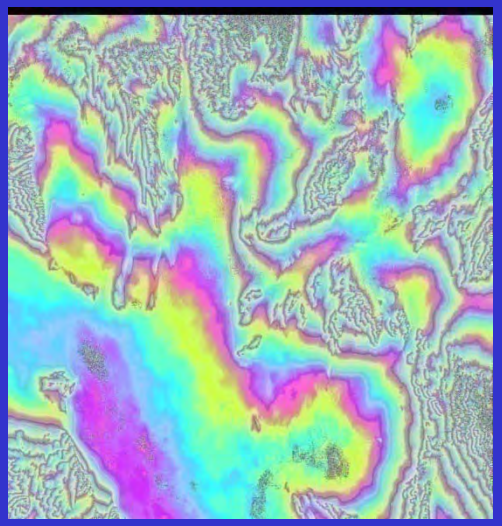
Uses data collected during two or more satellite passes

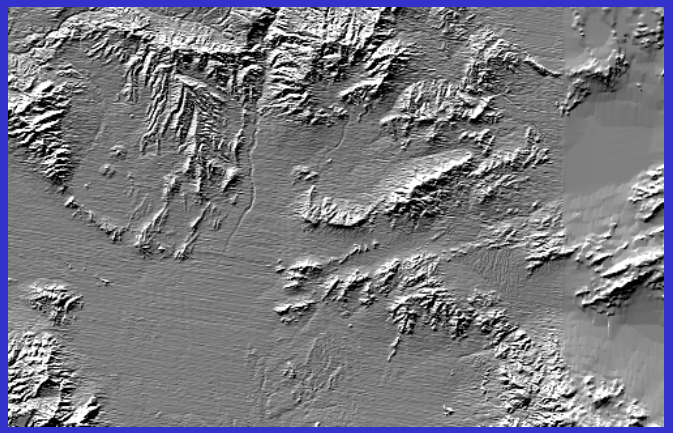


Slide Courtesy of the Vexcel Corporation

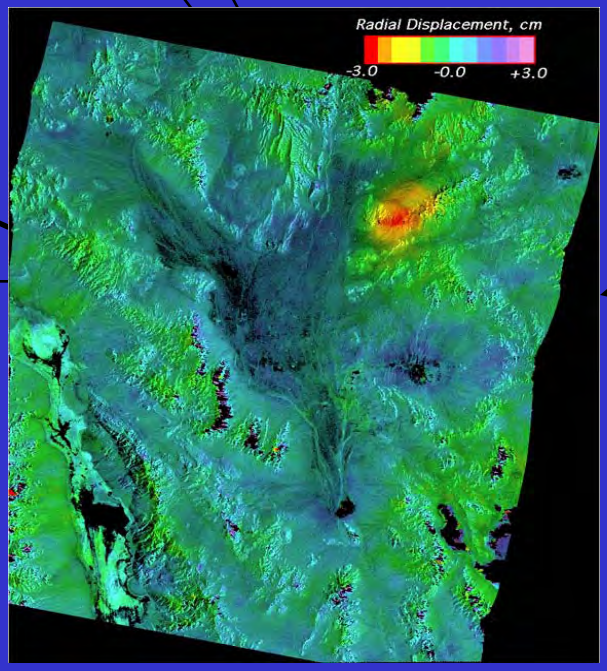
2-pass ERS, 11 month separation

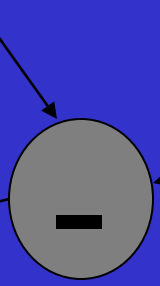


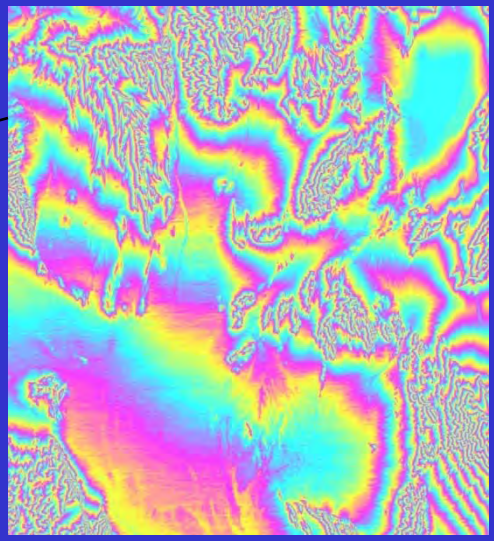




Simulate Phase from DEM







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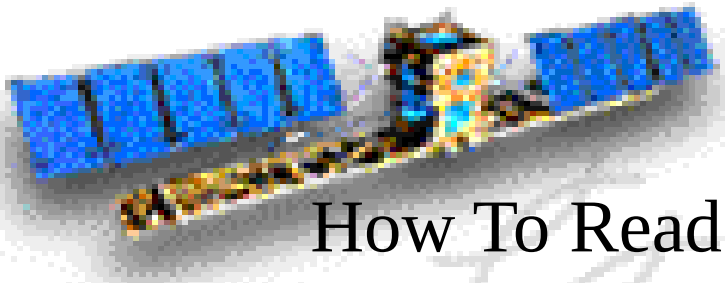
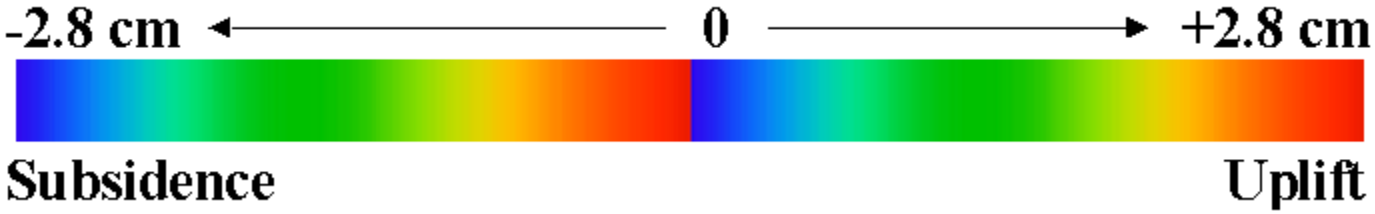


How To Read An Interferogram

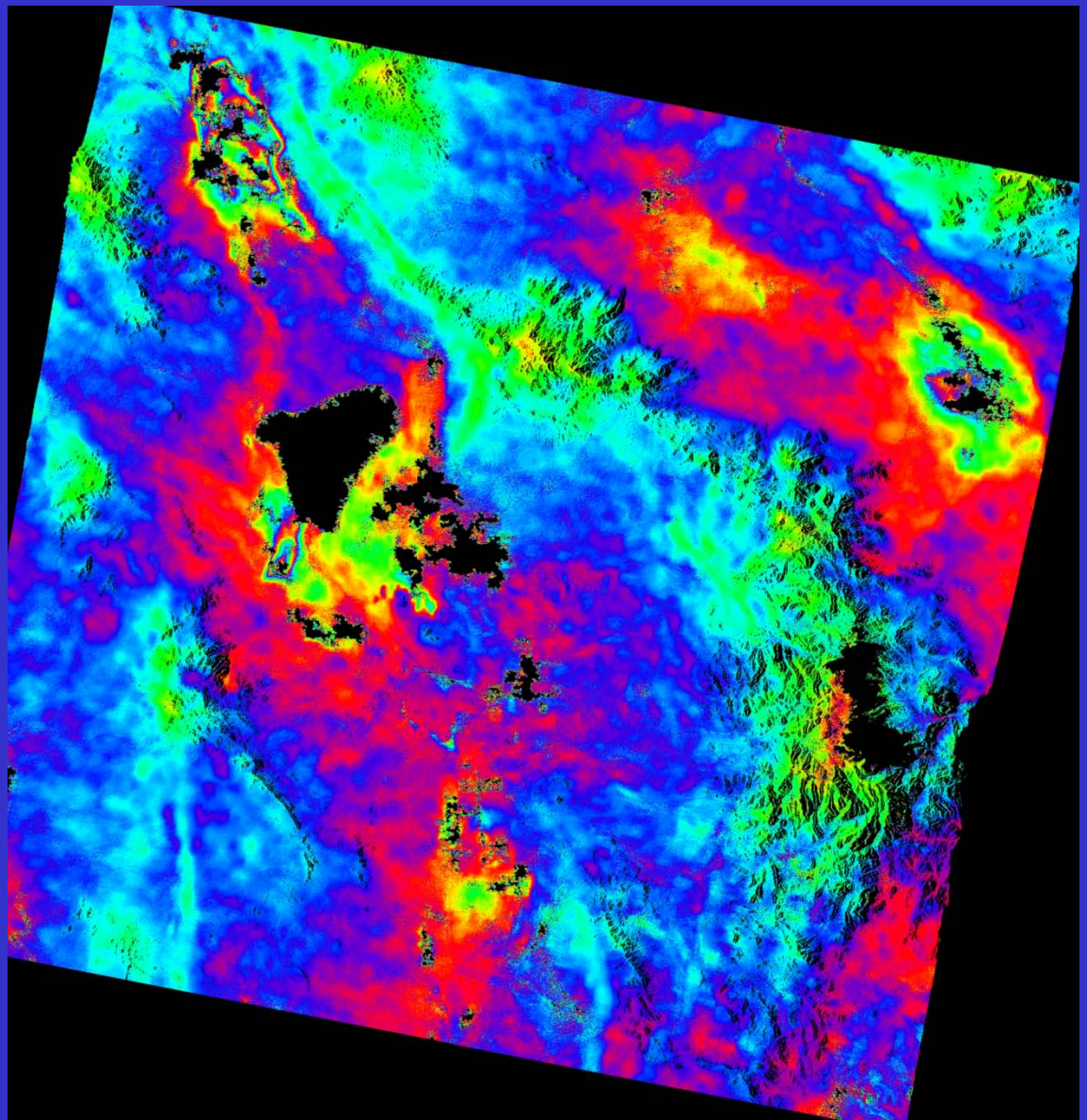
Explanation of the Interferogram Color Sequence



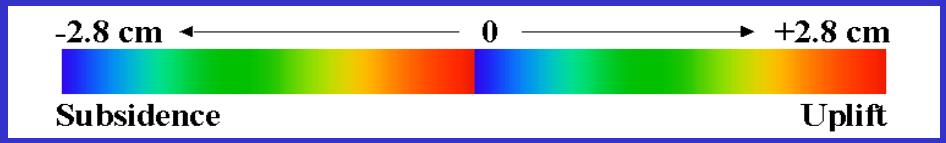
- Start on the outside of the color fringe pattern
- Count the number of color cycles to the center
- Each color cycle represents 2.8 cm of deformation (uplift or subsidence)

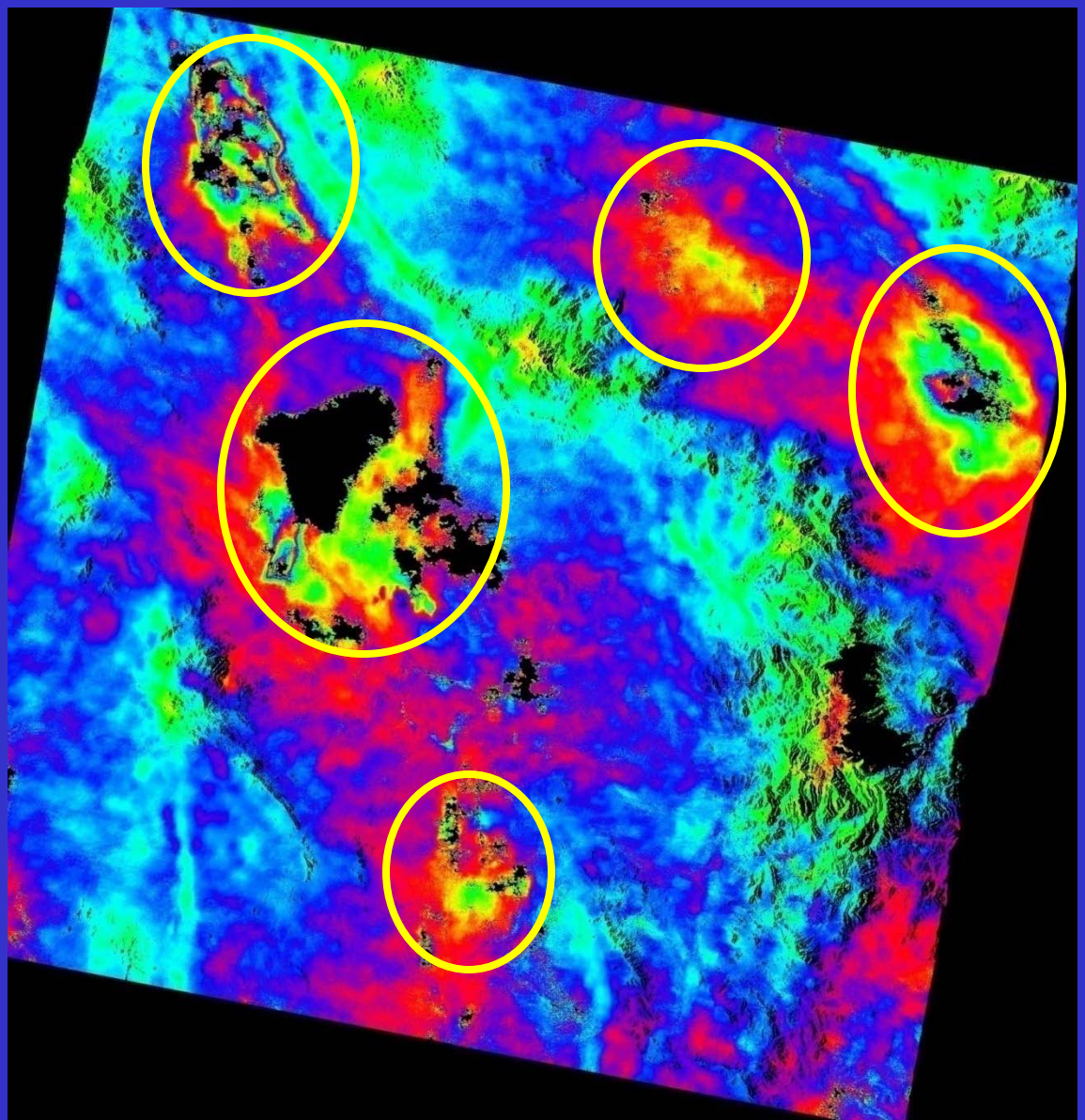
Do You See Any Areas of Deformation?

05/20/2008 to 10/07/2008 EnviSat Time-Series, Cochise County in Southeastern Arizona



Is It Subsidence or Uplift?





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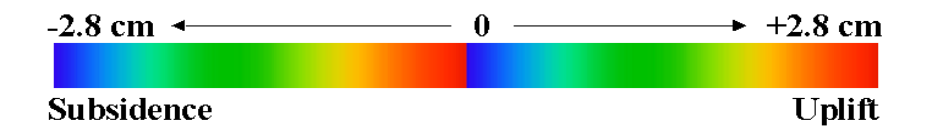
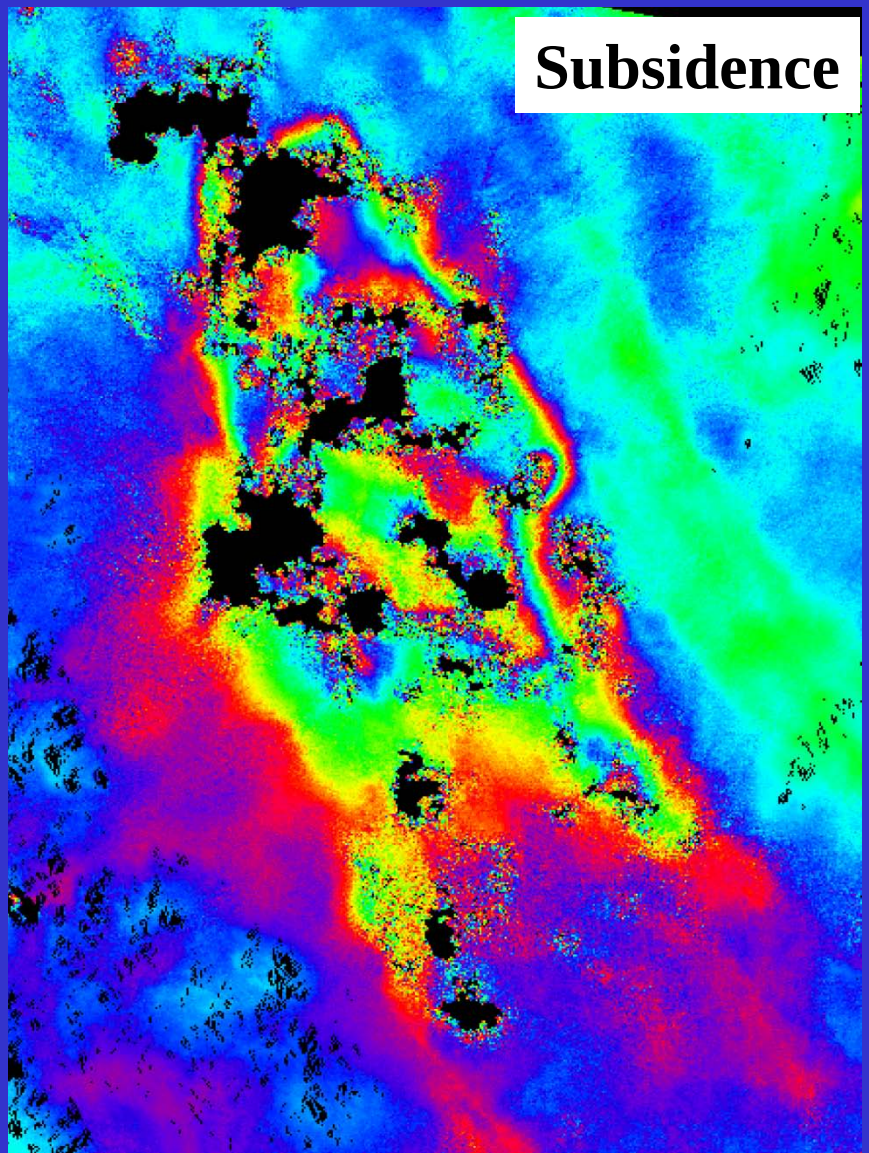
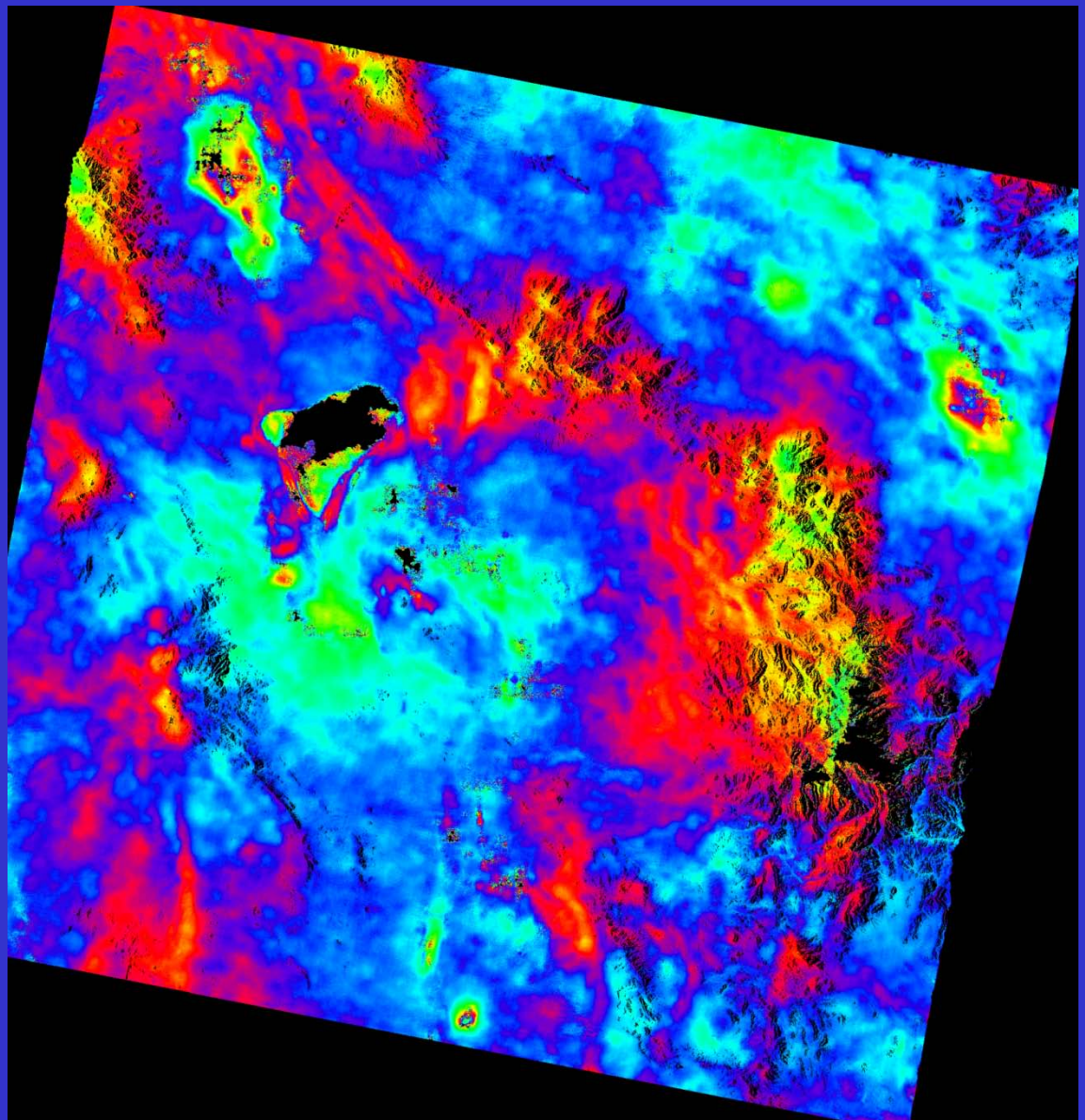


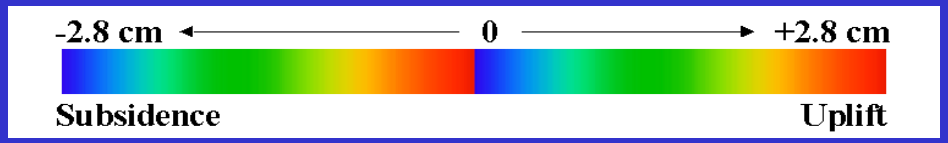


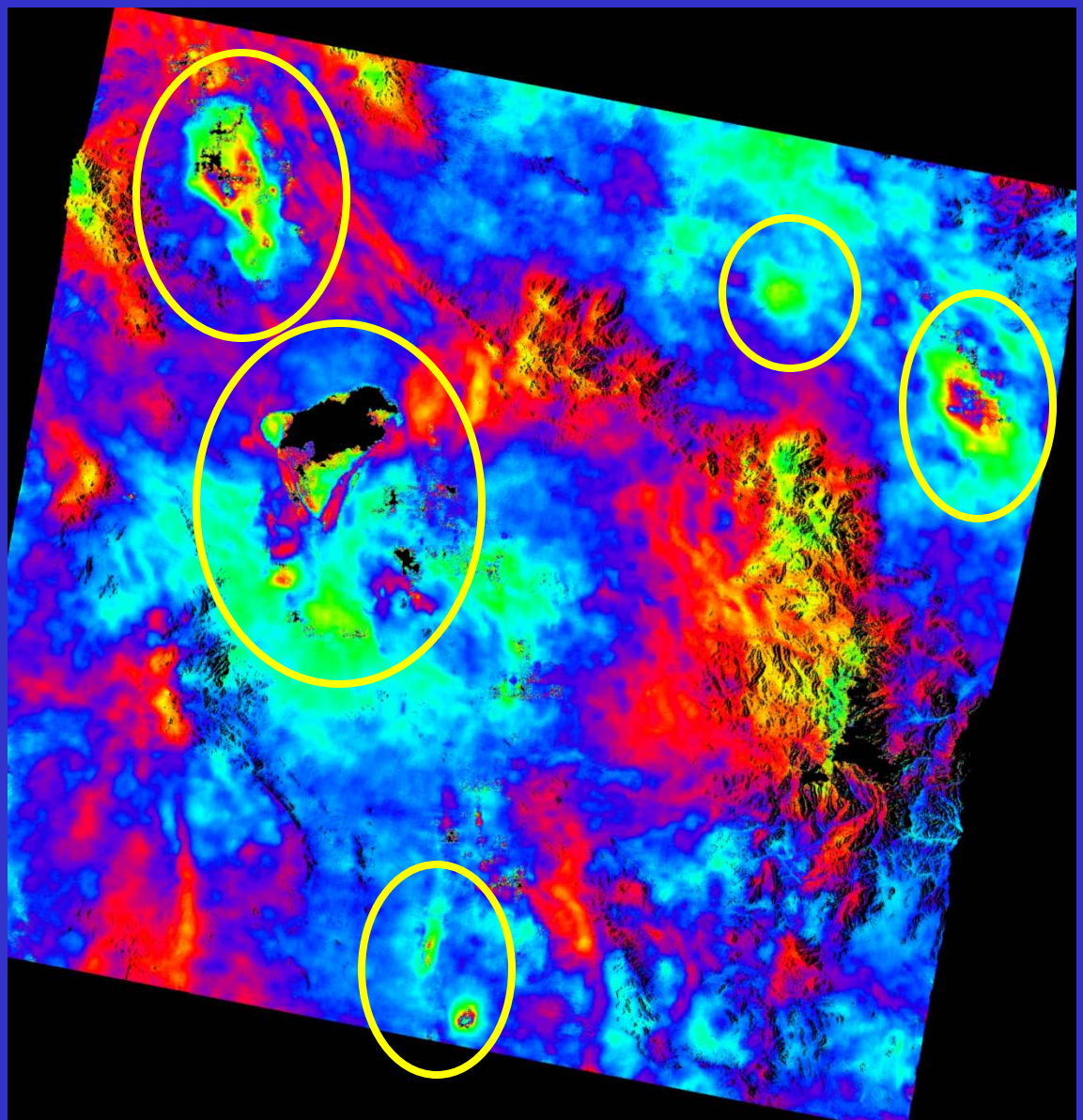
Do You See Any Areas of Deformation?

10/07/2008 to 01/20/2009 EnviSat Time-Series, Cochise County in Southeastern Arizona

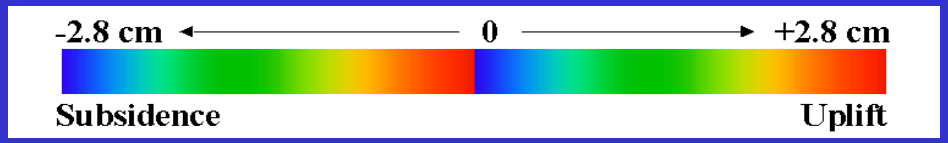


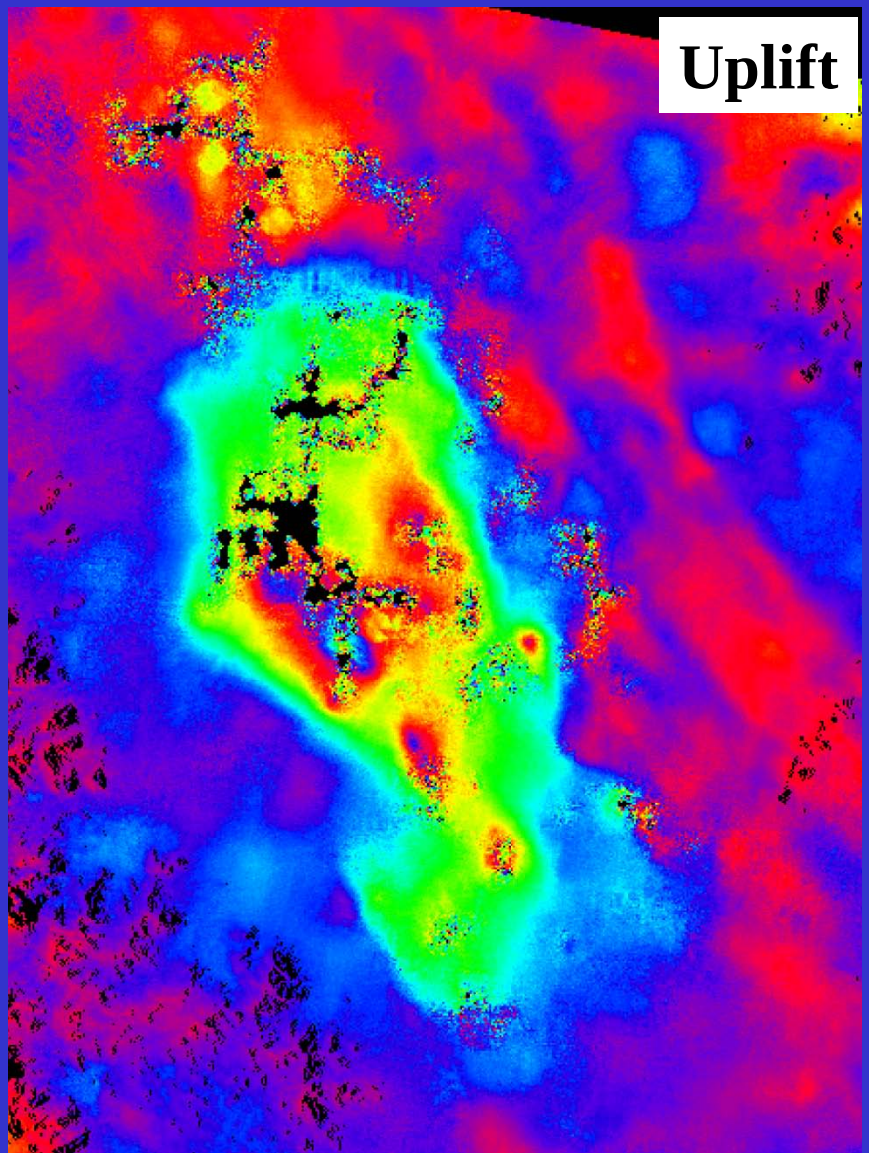
Is It Subsidence or Uplift?



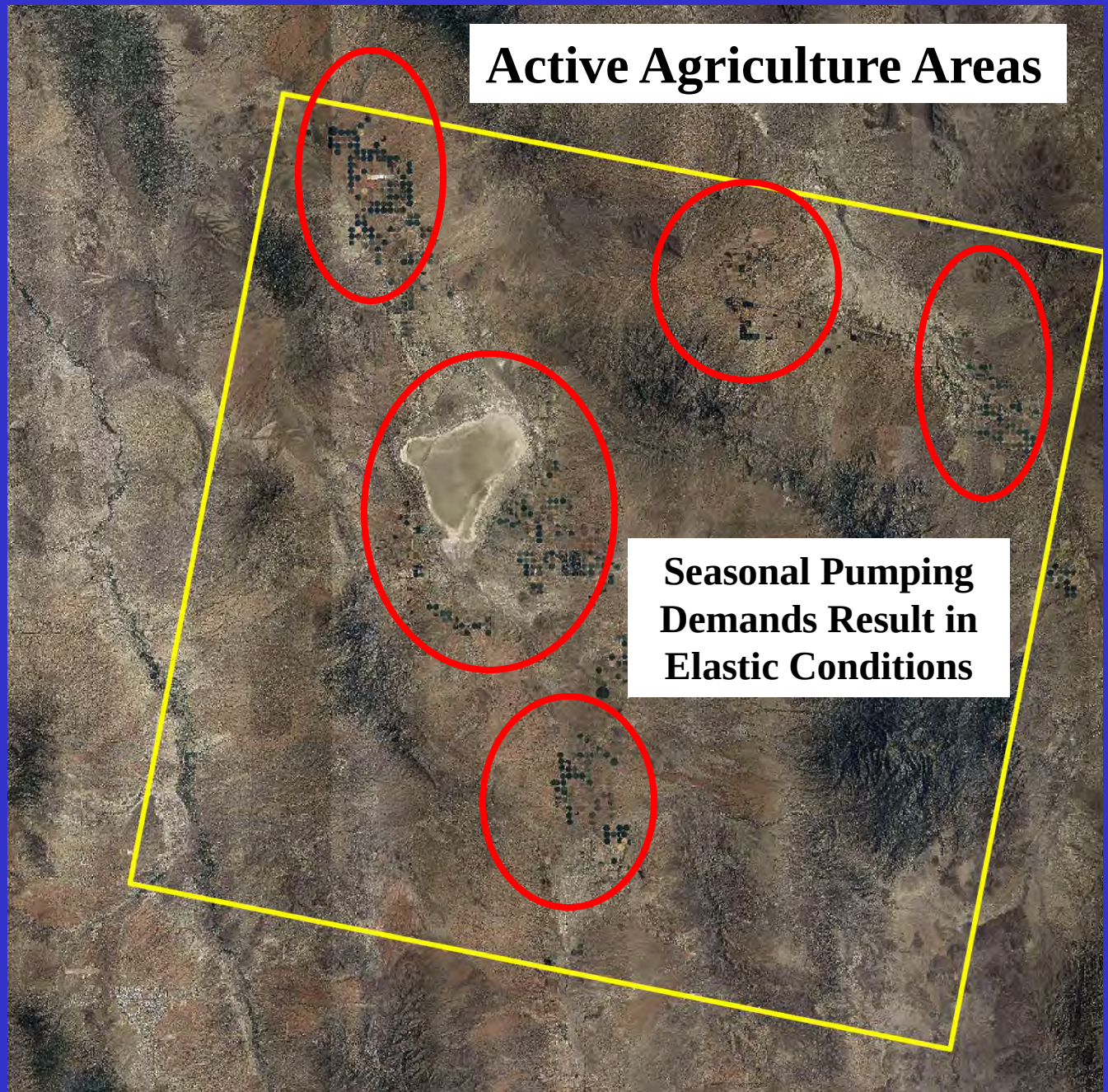


Is It Subsidence or Uplift?

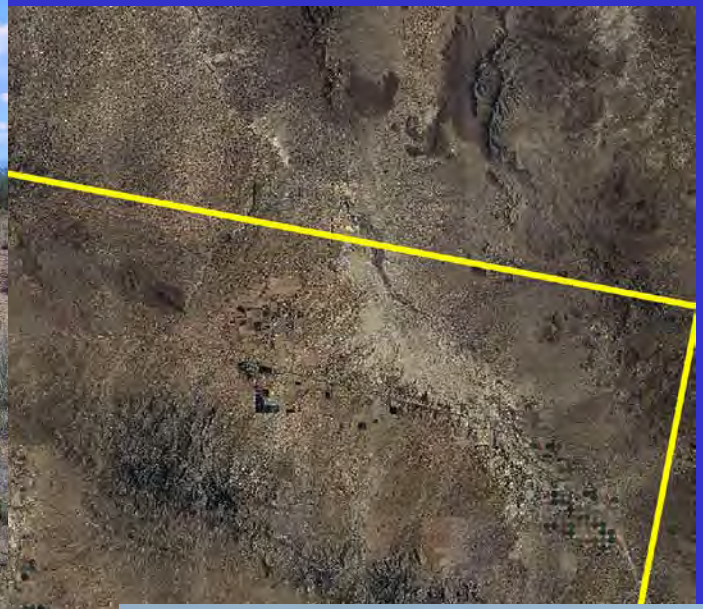


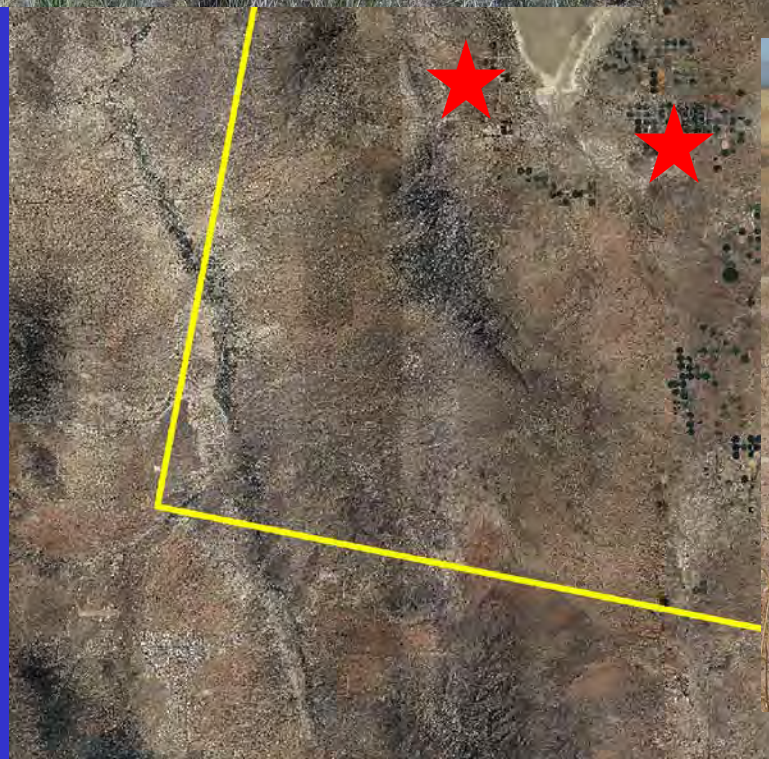


Why Subsidence and Uplift?



Evidence of Land Subsidence





Land Subsidence Monitoring In Arizona Using InSAR

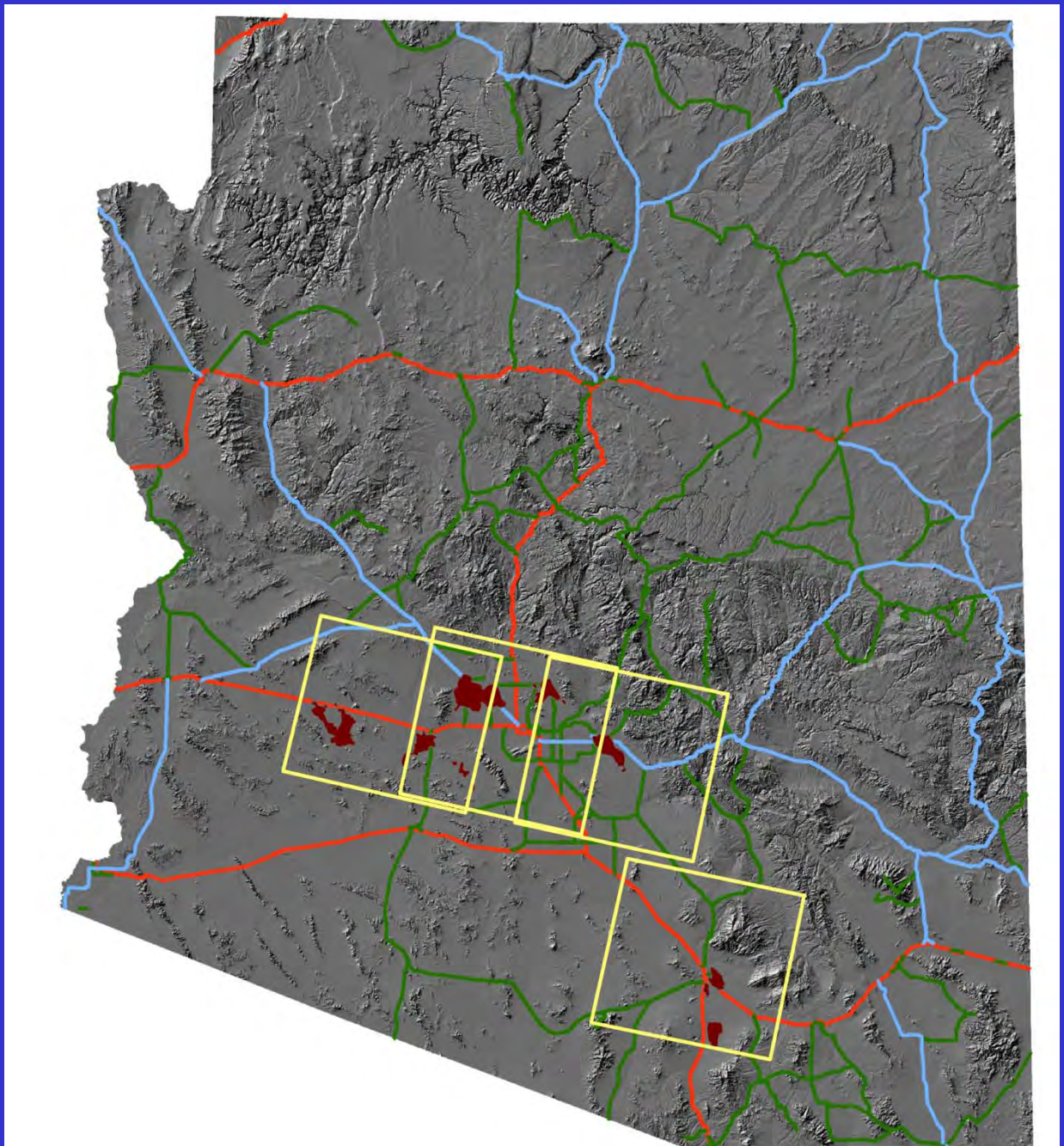
Started Looking At:

Phoenix and Tucson Metropolitan Areas

Using Four Satellite Frames

Identified Nine Subsidence Features

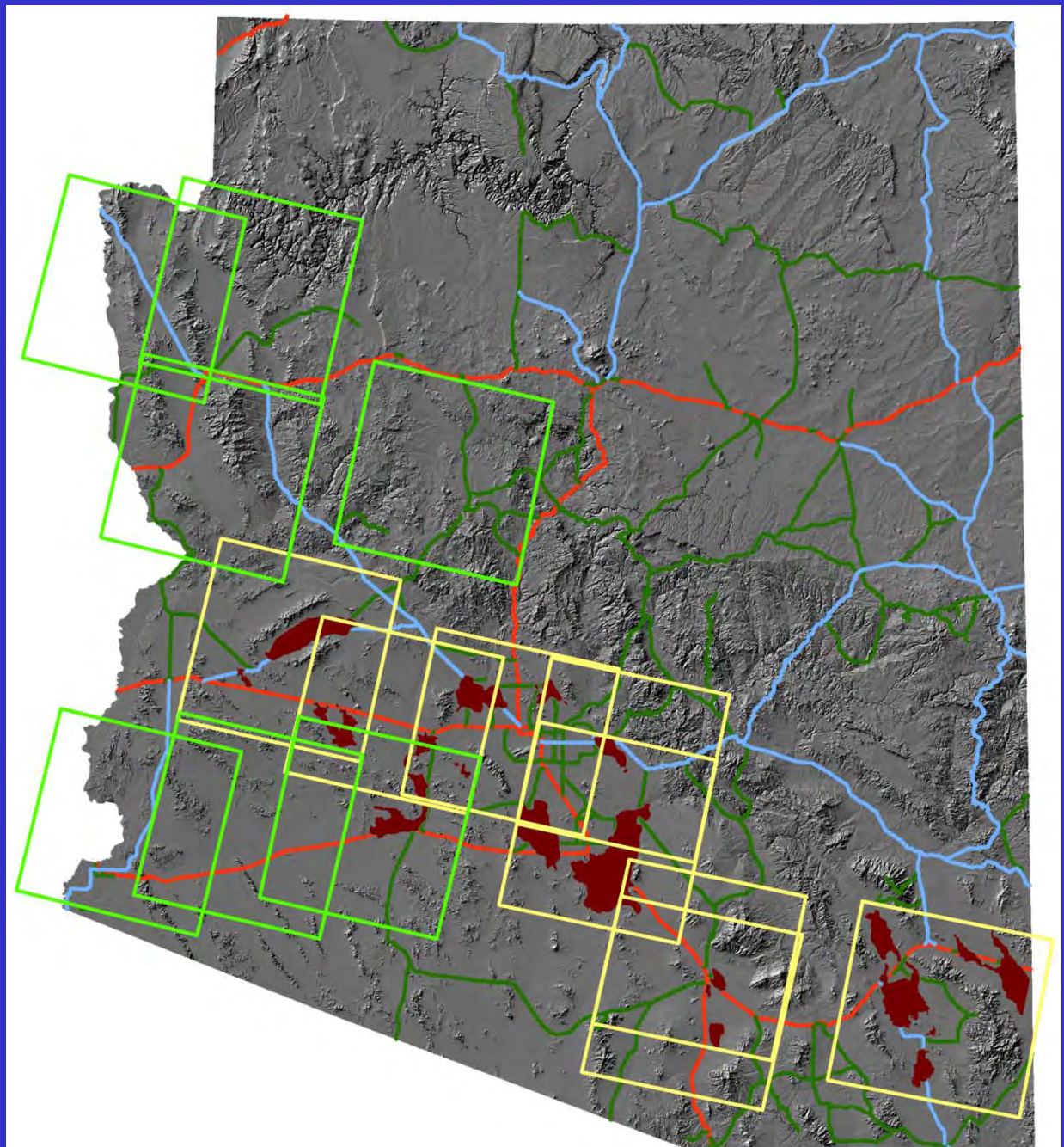
Started to monitor and collect InSAR data every month

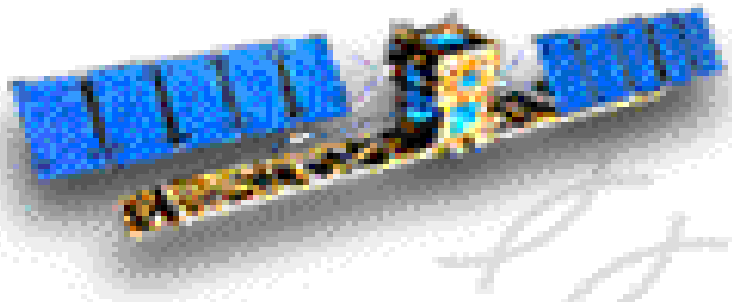


Land Subsidence Monitoring In Arizona Using InSAR

Expanded InSAR program through cooperative efforts and external funding.

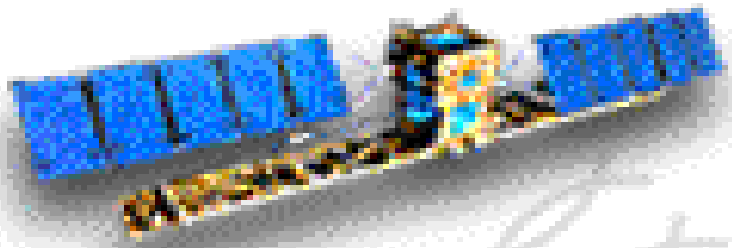
ADWR currently collects seven InSAR frames a month and have identified more than eighteen land subsidence features in Central and Southern Arizona





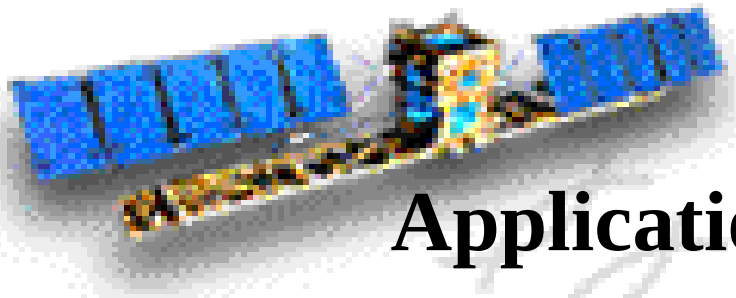
ADWR InSAR Program

Applications of InSAR



Cooperators Who Contribute to the ADWR InSAR Program

- **Flood Control District of Maricopa County**
- **Pinal County Flood Control District**
- **Arizona Department of Transportation**
- **Arizona State Land Department**
- **Central Arizona Project**
- **Metropolitan Domestic Water Improvement District**
- **Salt River Project**
- **Community Water Company**
- **City of Scottsdale**

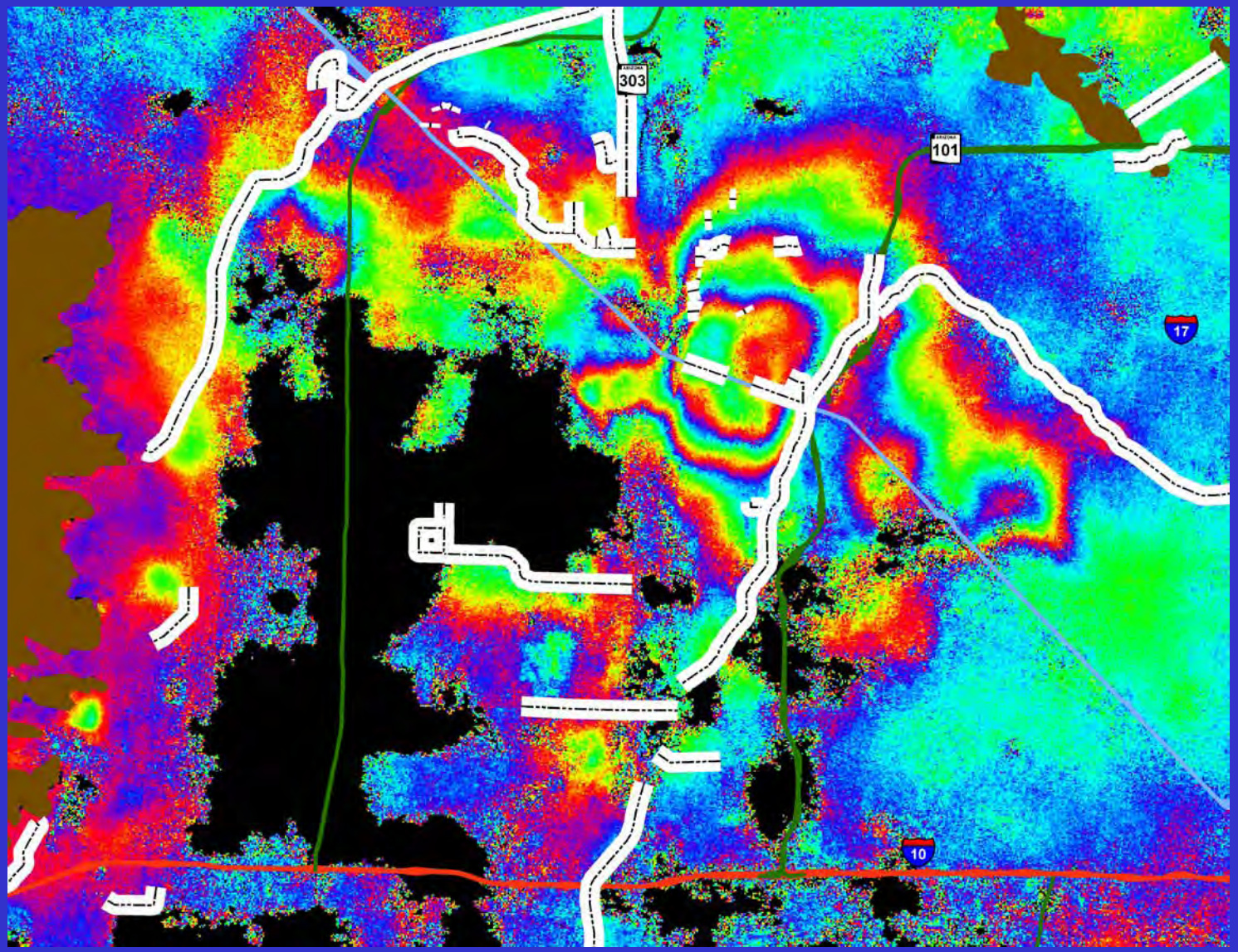


Applications of InSAR

- **Land subsidence monitoring.**
- **Monitoring seasonal deformation (subsidence and uplift).**
- **Monitoring natural and artificial recharge events.**
- **Geological mapping and investigations.**
- **Locating earth fissures and areas where conditions may exist for earth fissure formation.**
- **Dam mitigation and land subsidence modeling.**

InSAR Used For Land Subsidence Monitoring and Modeling Along A Flood Control Structure

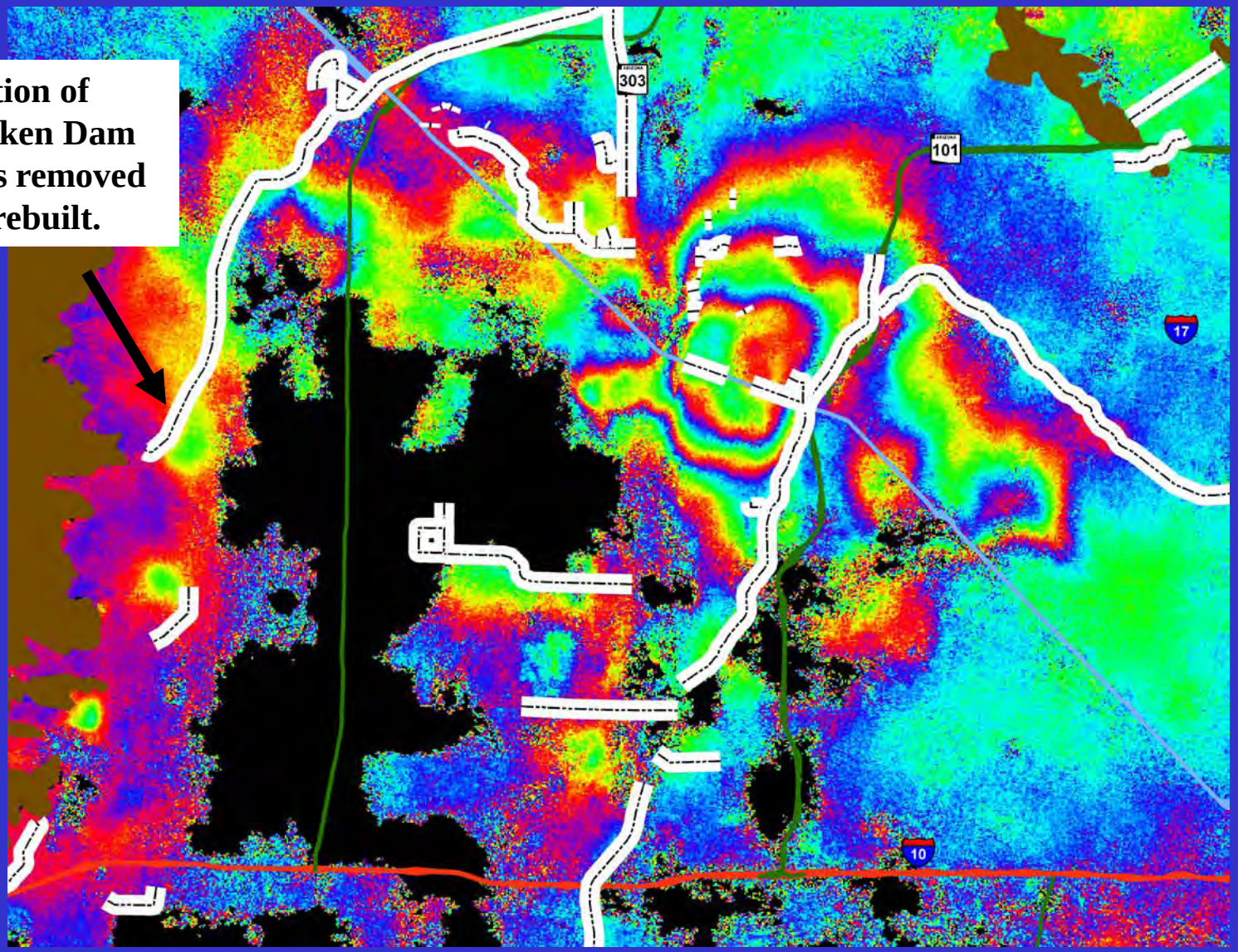
FCDMC McMicken Dam, White Tank Mountains, 03/08/2004 To 02/11/2008



InSAR Used For Land Subsidence Monitoring and Modeling Along A Flood Control Structure

FCDMC McMicken Dam, White Tank Mountains, 03/08/2004 To 02/11/2008

Portion of McMicken Dam that was removed and rebuilt.



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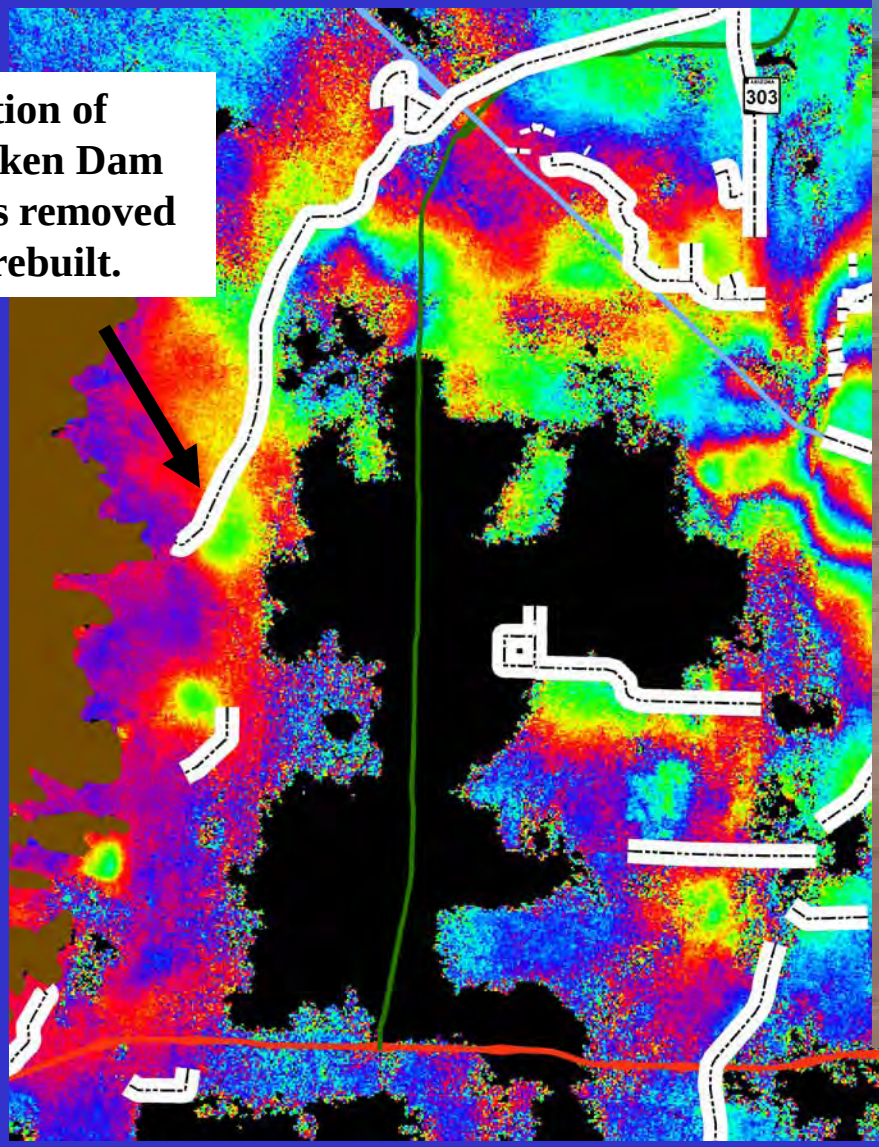

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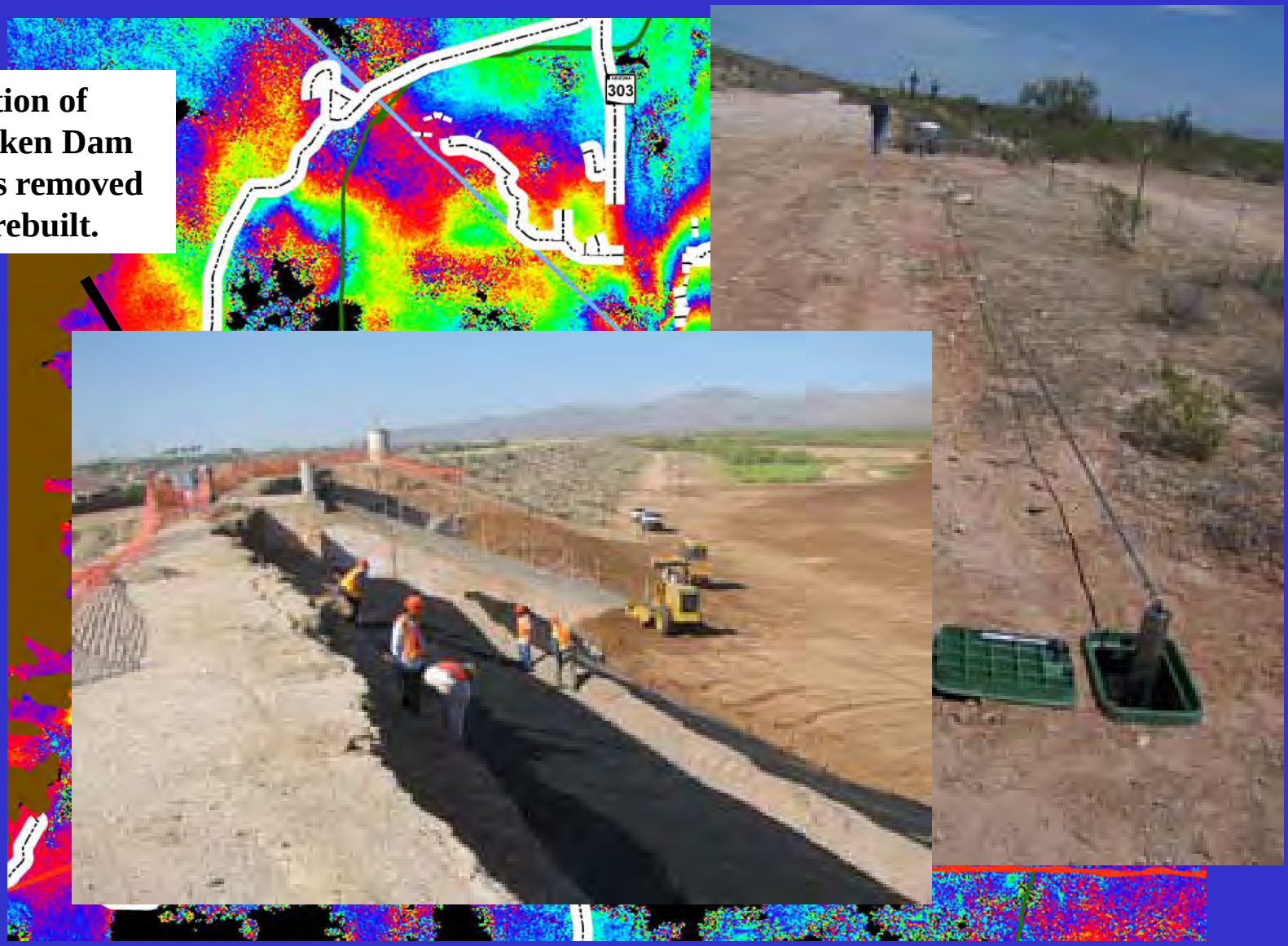
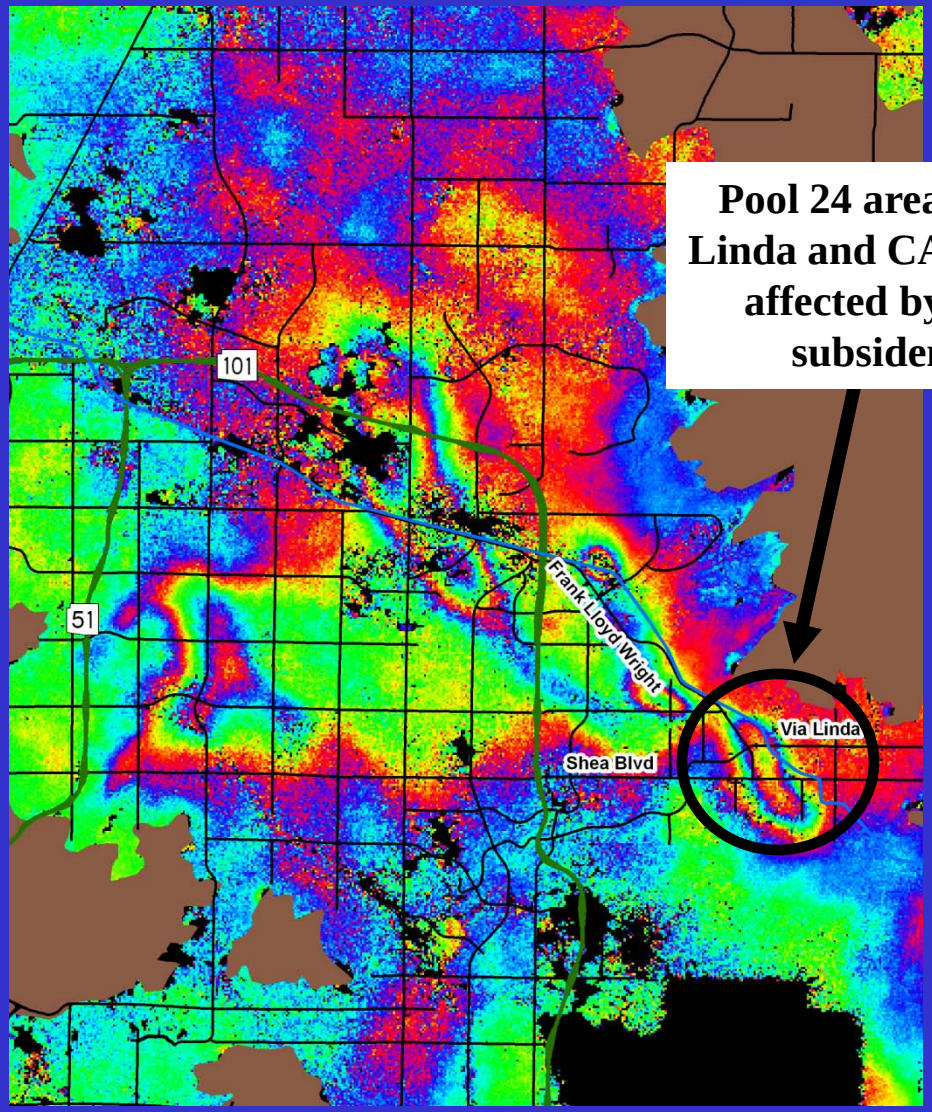


InSAR Used For Land Subsidence Monitoring and Modeling Along the Central Arizona Project Canal

CAP Canal Pool 23 and 24 Areas, NE Phoenix/Scottsdale, 07/10/1992 To 10/30/2000



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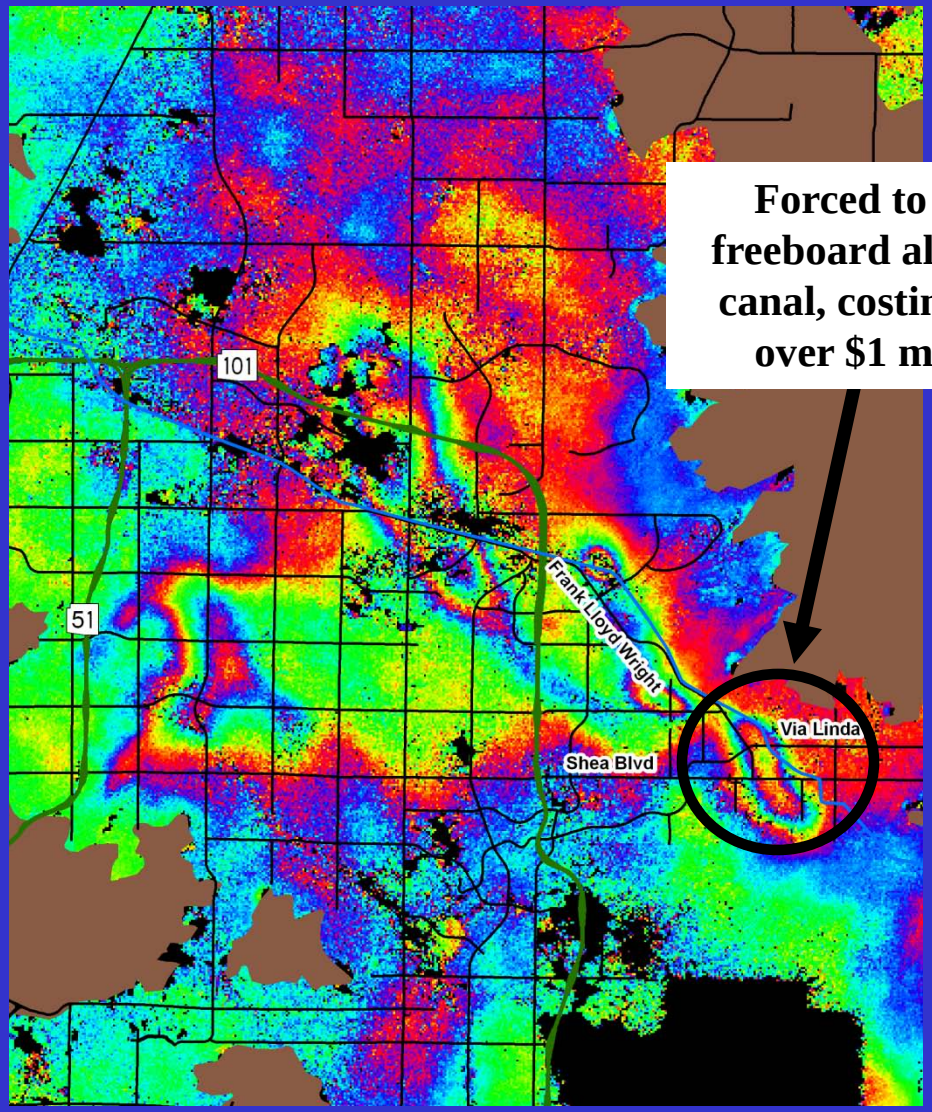
CAP Canal Pool 23 and 24 Areas, NE Phoenix/Scottsdale, 07/10/1992 To 10/30/2000

Pool 24 area at Via Linda and CAP Canal affected by land subsidence

InSAR Used For Land Subsidence Monitoring and Modeling Along the Central Arizona Project Canal

CAP Canal Pool 23 and 24 Areas, NE Phoenix/Scottsdale, 07/10/1992 To 10/30/2000



Forced to raise freeboard along the canal, costing CAP over $1 million

InSAR Used For Land Subsidence Monitoring and Modeling Along the Central Arizona Project Canal

CAP Canal Pool 23 and 24 Areas, NE Phoenix/Scottsdale, 07/10/1992 To 10/30/2000

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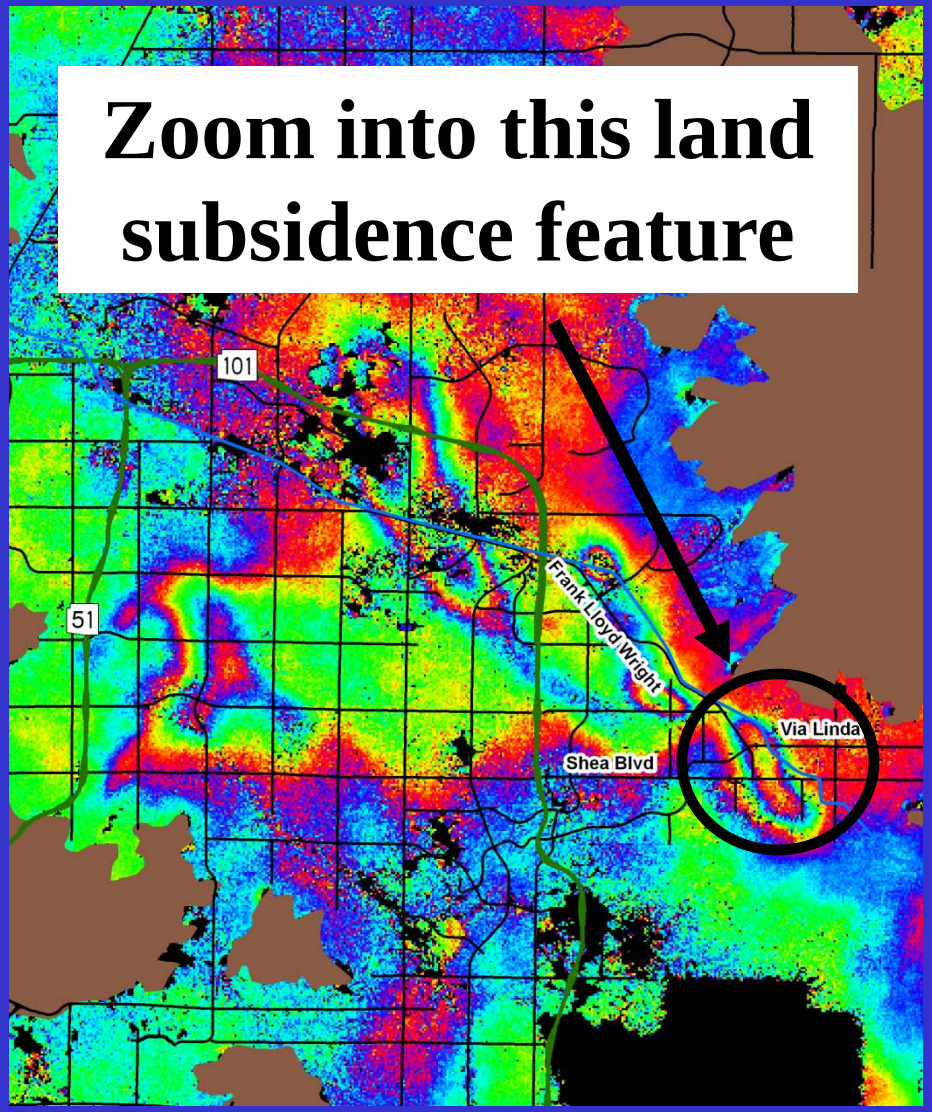

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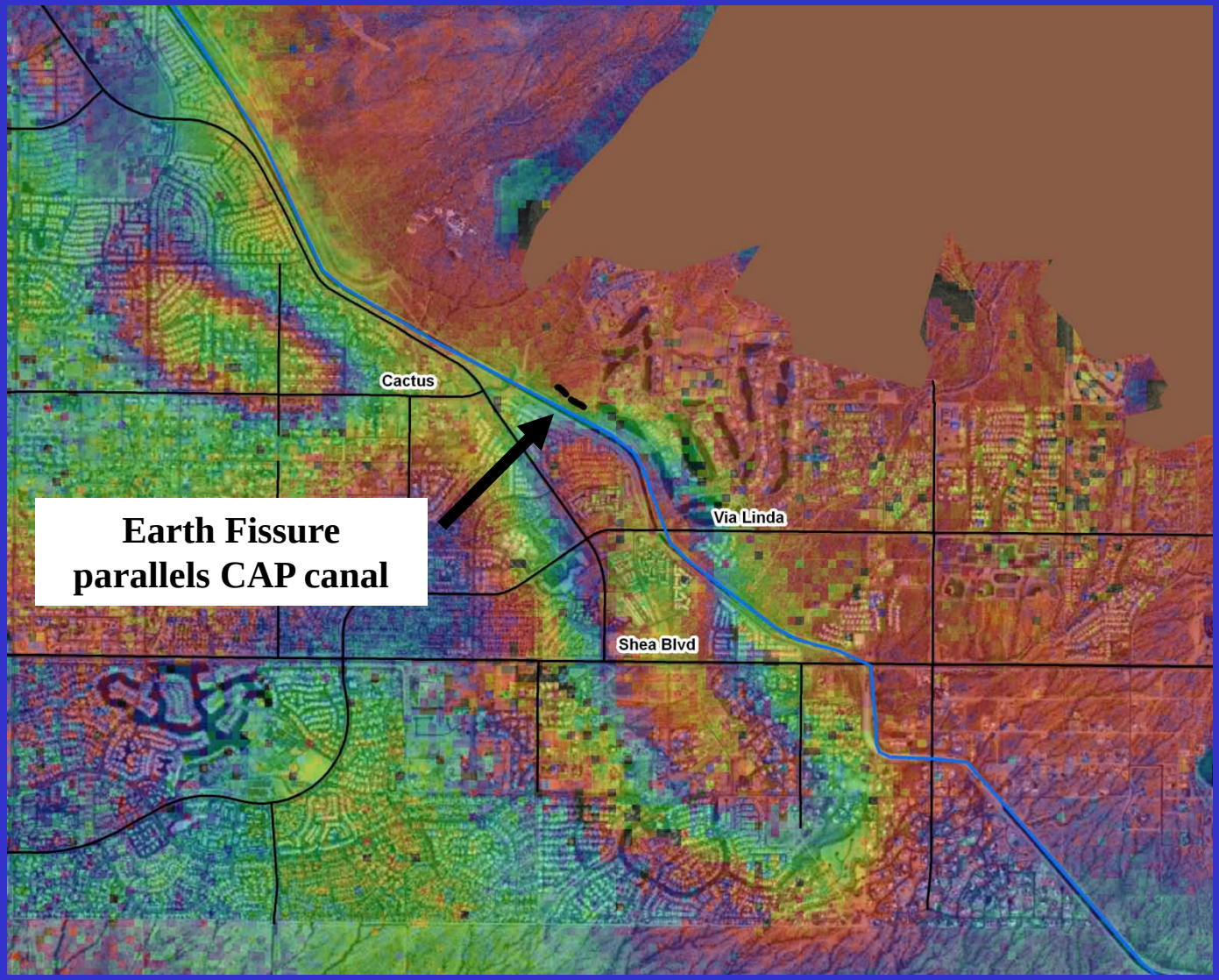

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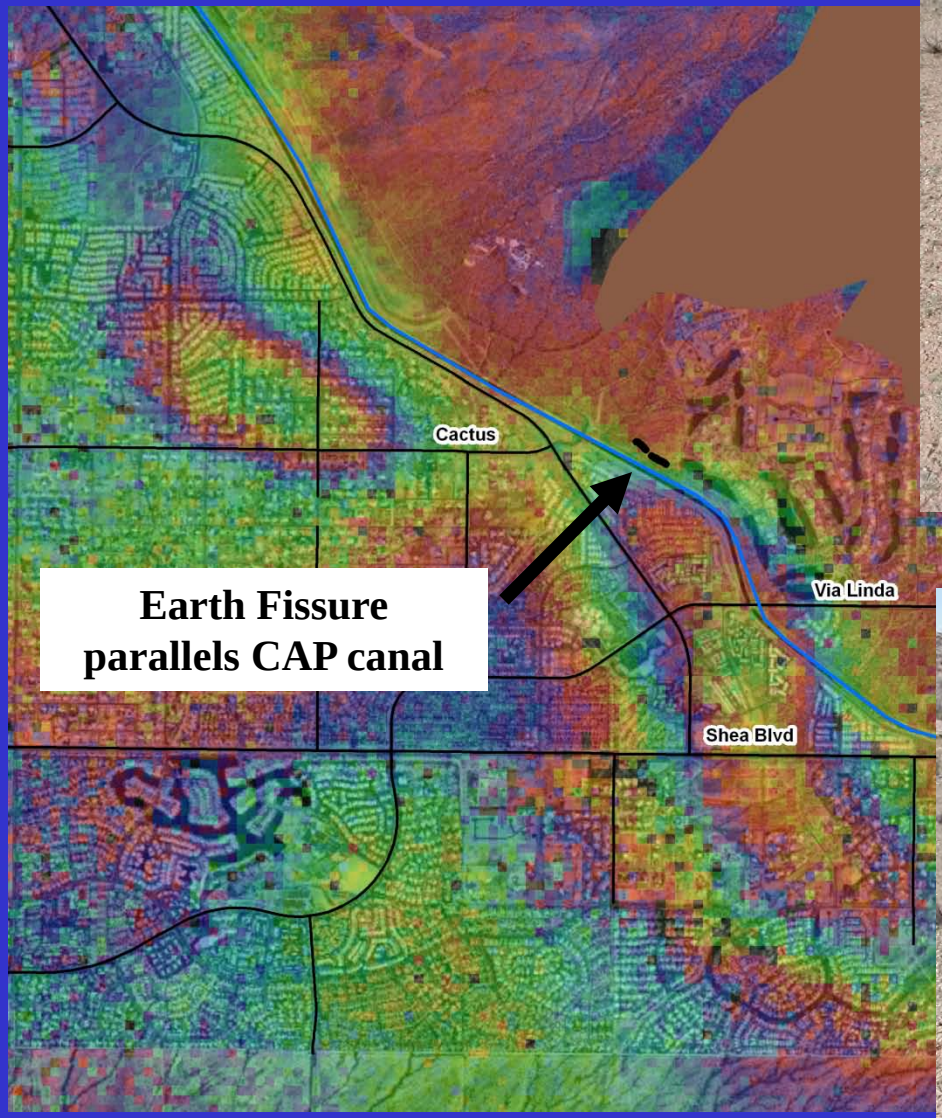
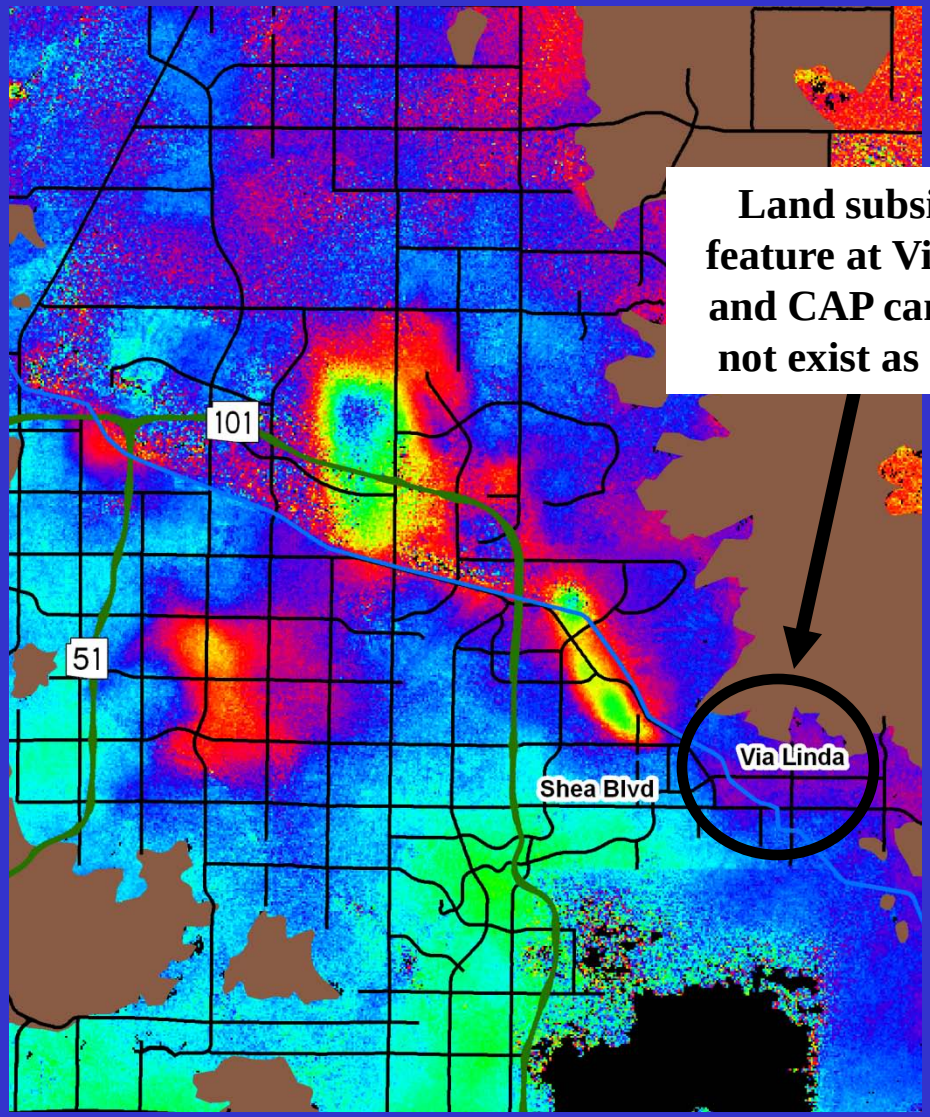
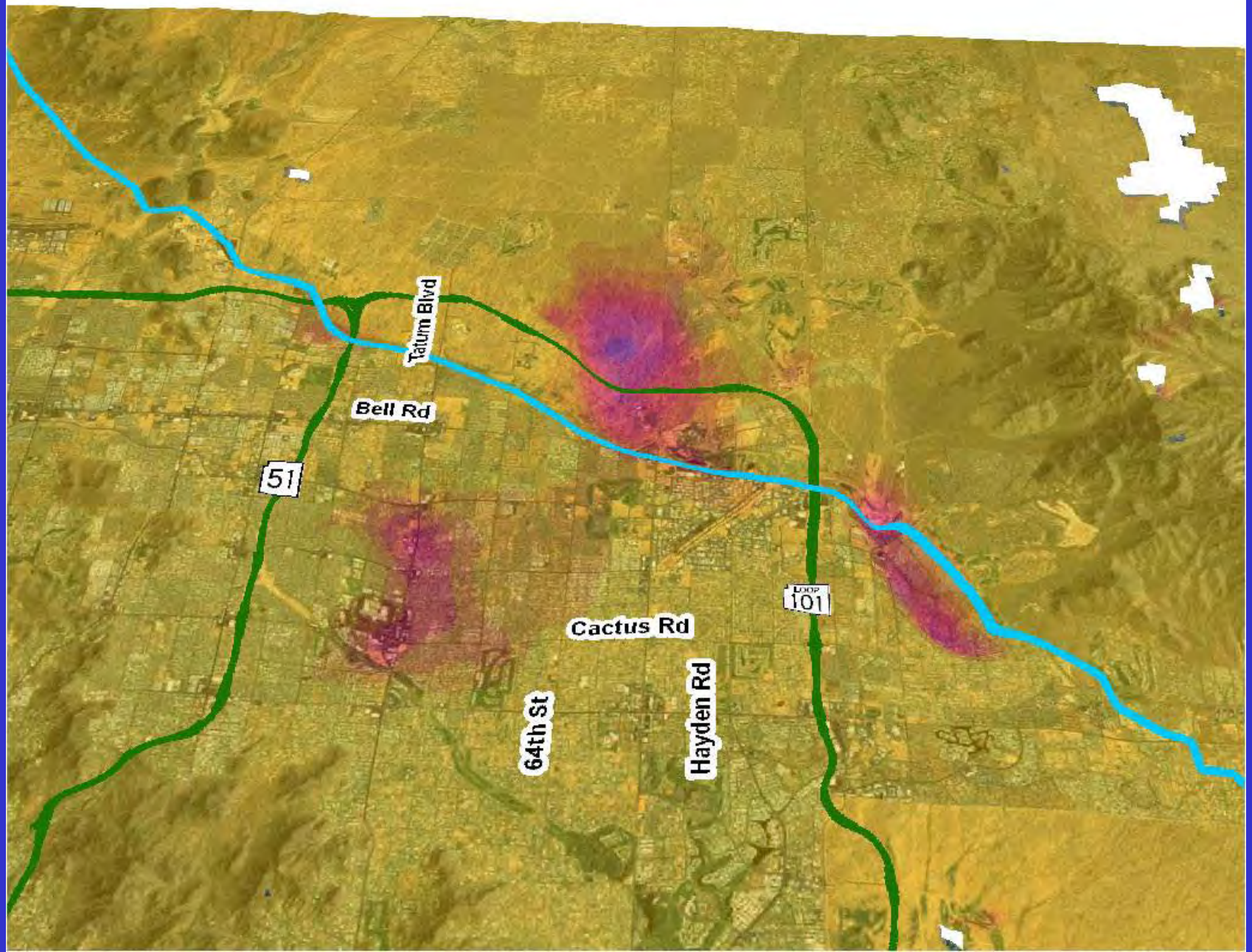


InSAR Used For Land Subsidence Monitoring and Modeling Along the Central Arizona Project Canal

CAP Canal Pool 23 and 24 Areas, NE Phoenix/Scottsdale, 02/11/2008 to 02/15/2010

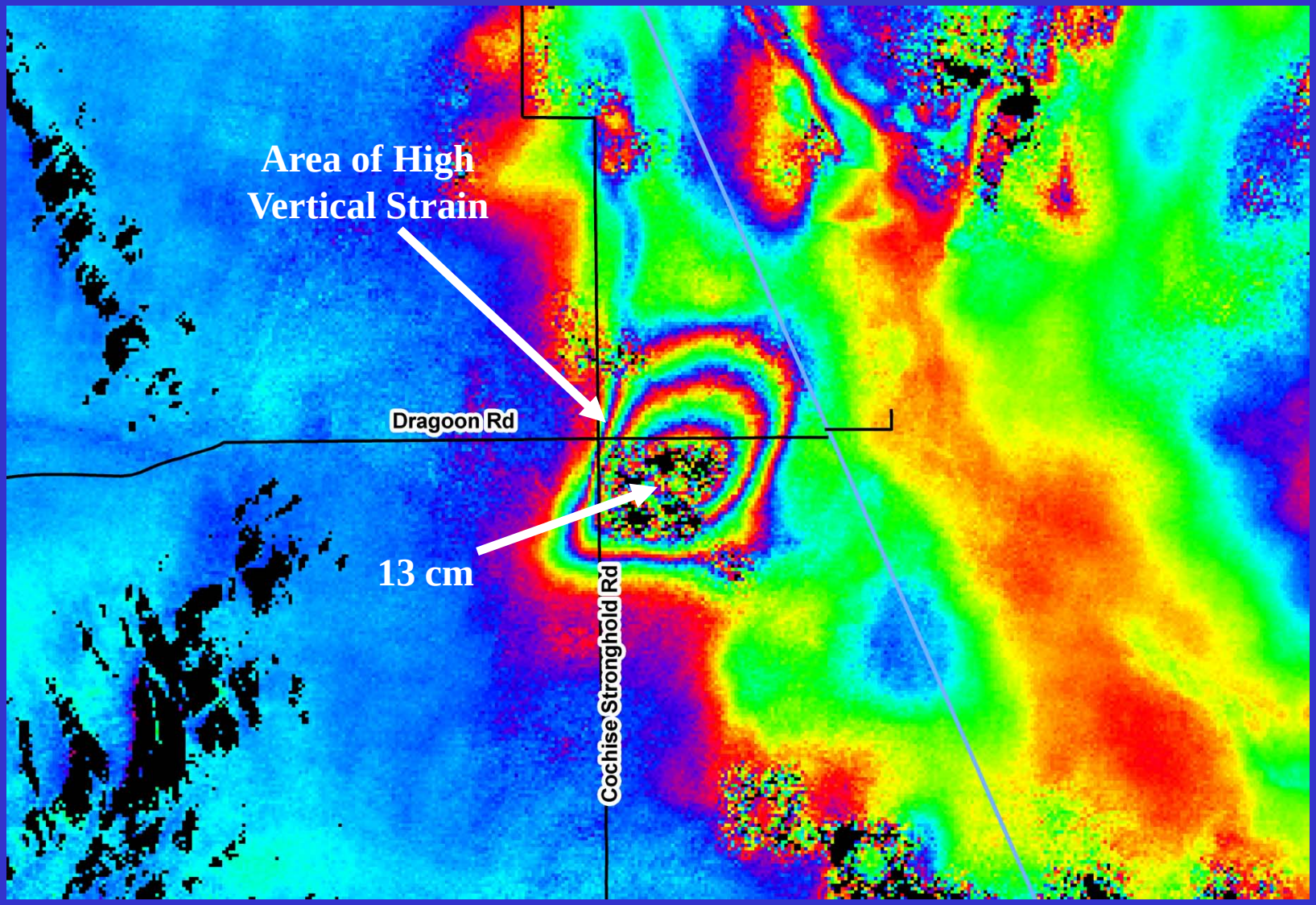


Virtual View of Land Subsidence for the Northeast Phoenix/Scottsdale Area in Maricopa County


Tatum Blvd
Bell Rd
51
Cactus Rd
64th St
Hayden Rd
LOOP
101

InSAR Used For Earth Fissure Monitoring

Willcox Basin/Cochise County, 10 miles southwest of the Town of Willcox 01/20/2009 To 01/05/2010



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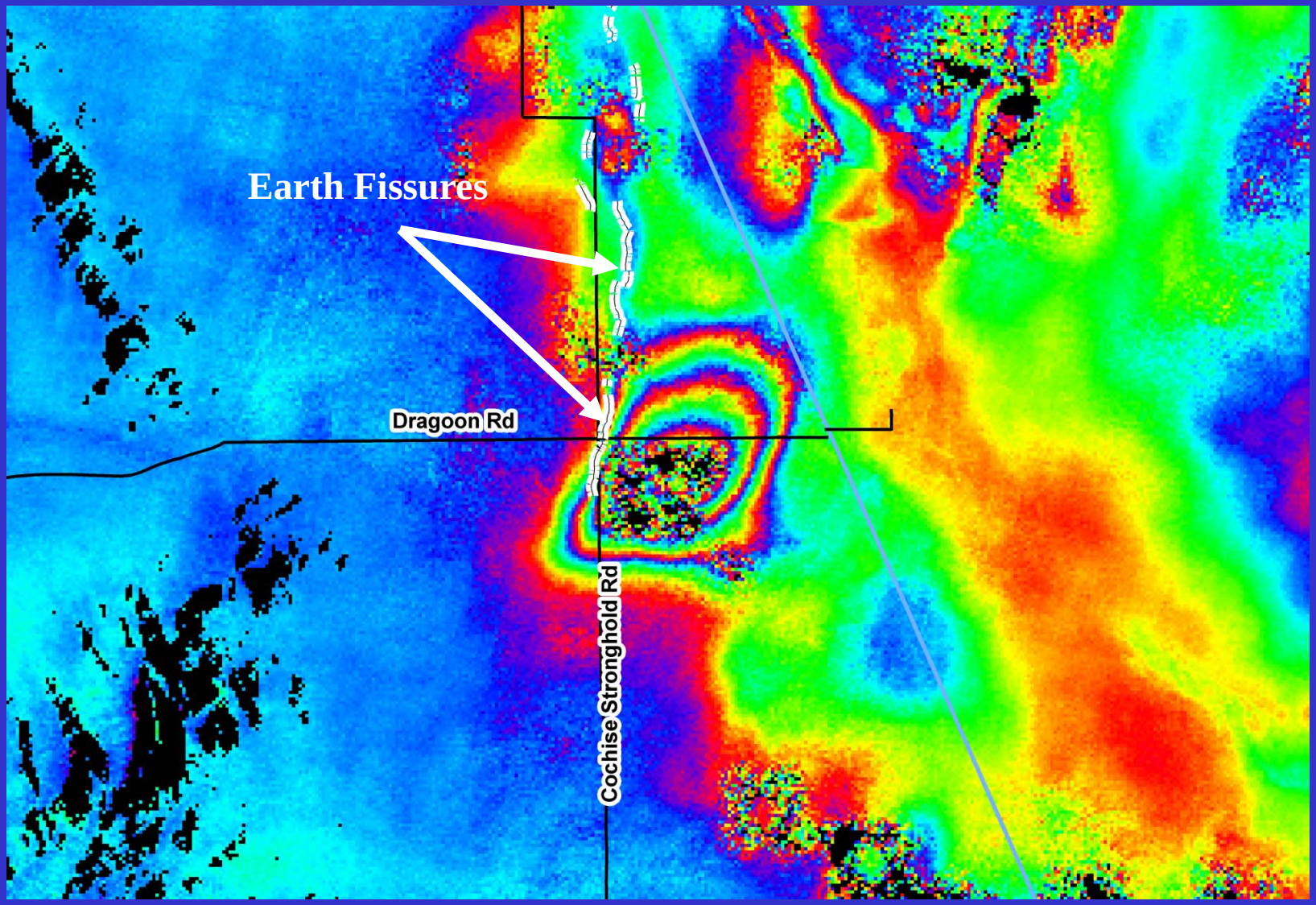
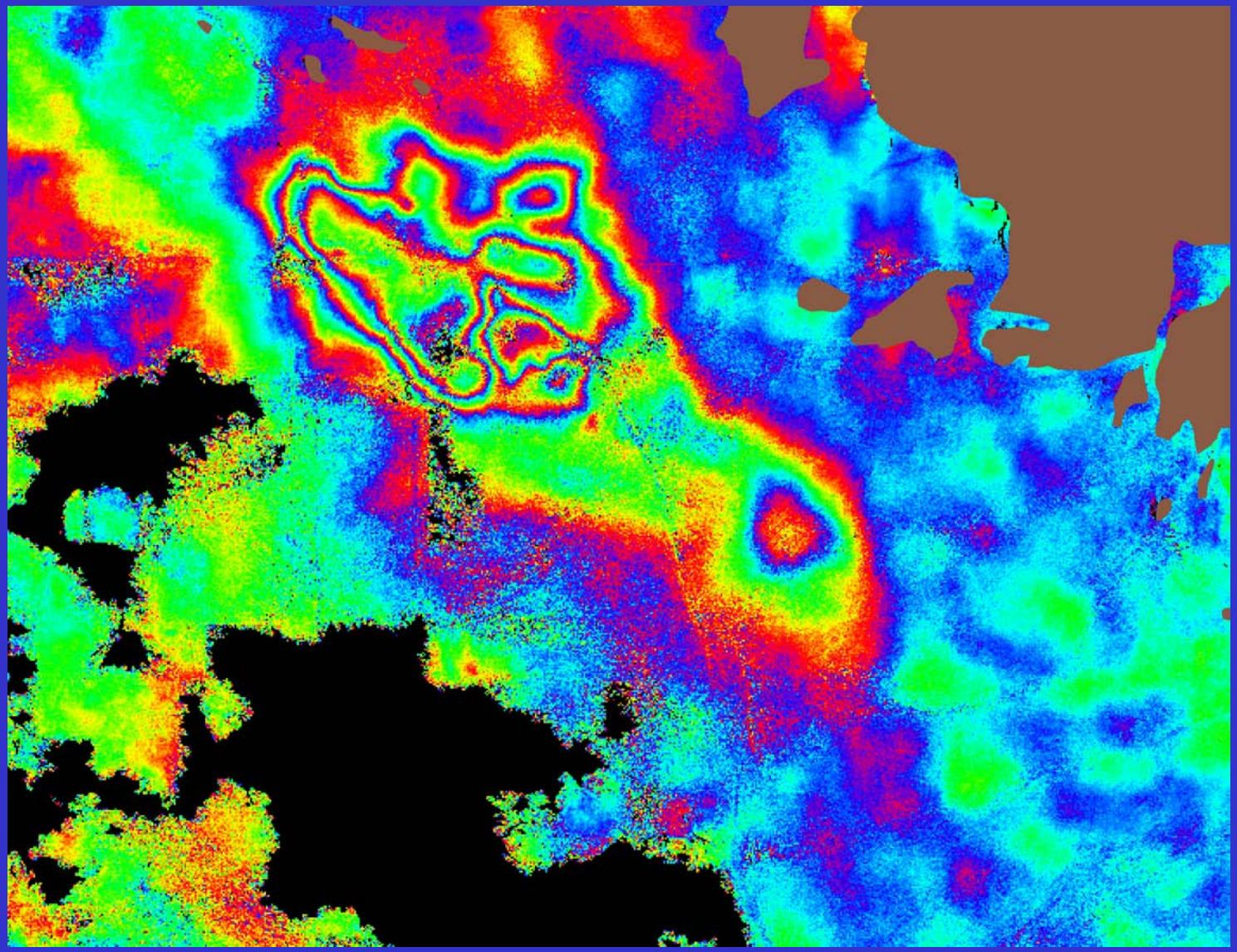


InSAR Used For Geological Investigations

Hawk Rock Area, East Mesa/Apache Junction, Pinal/Maricopa Counties 10/20/2004 To 04/02/2008



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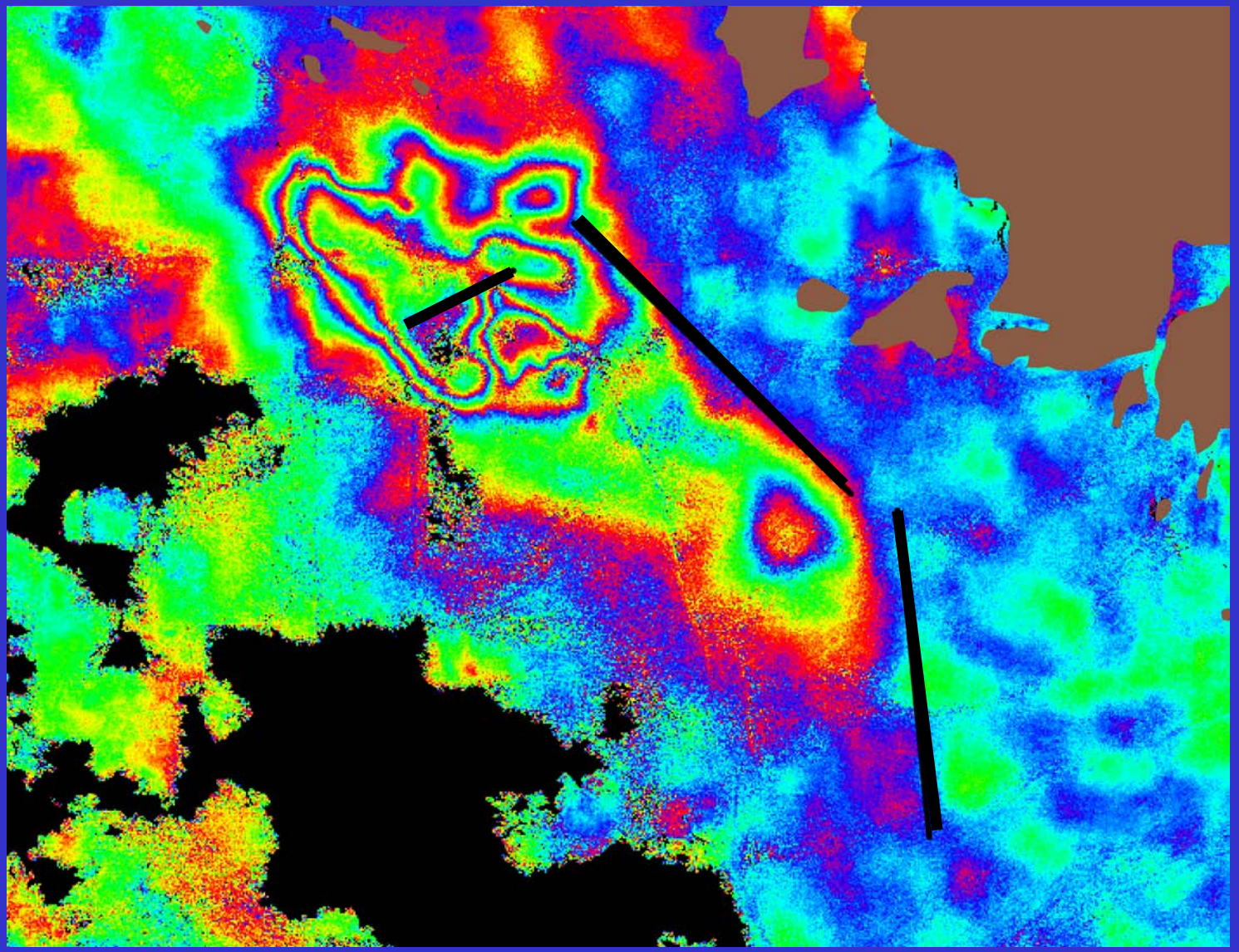

InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County

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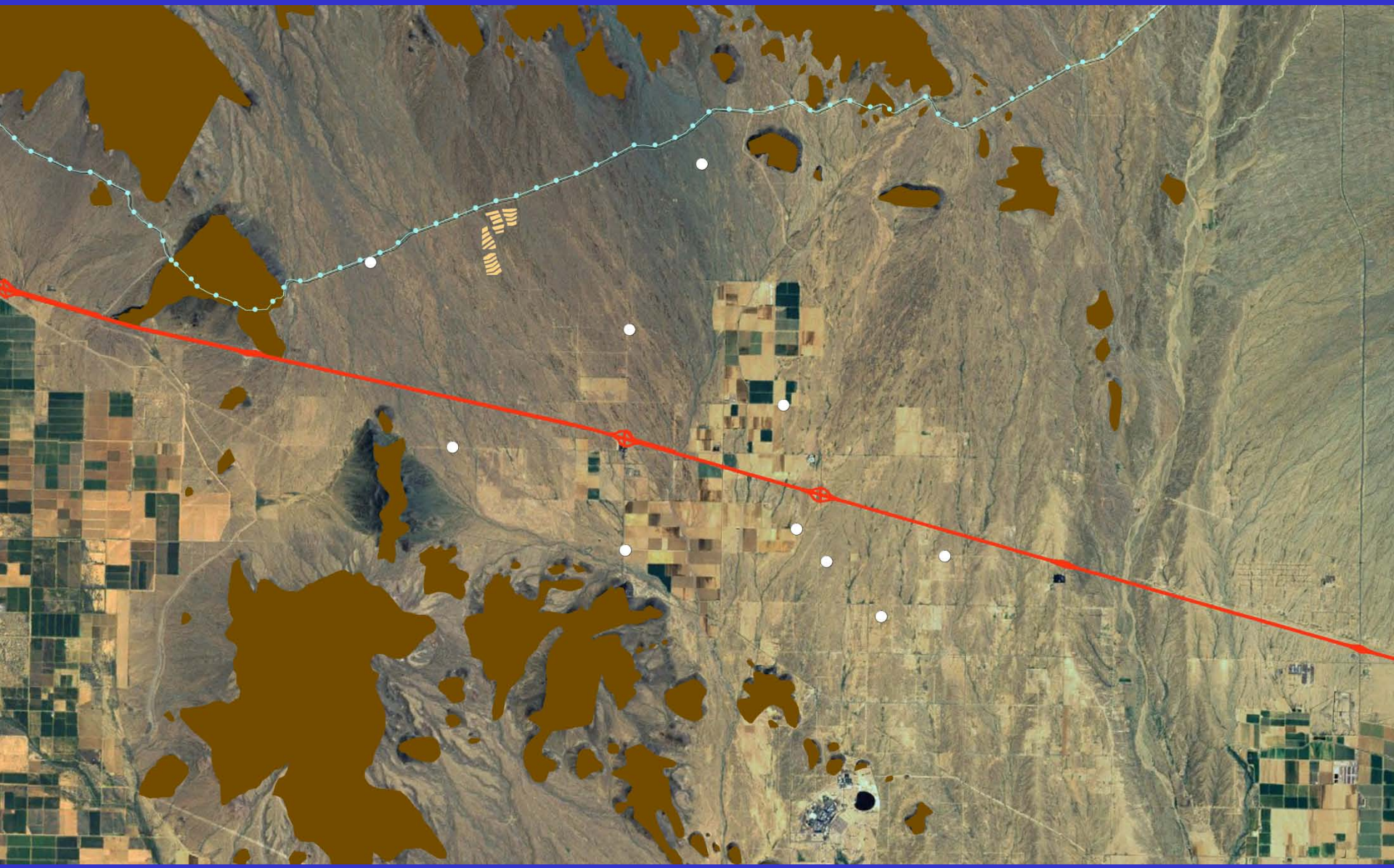
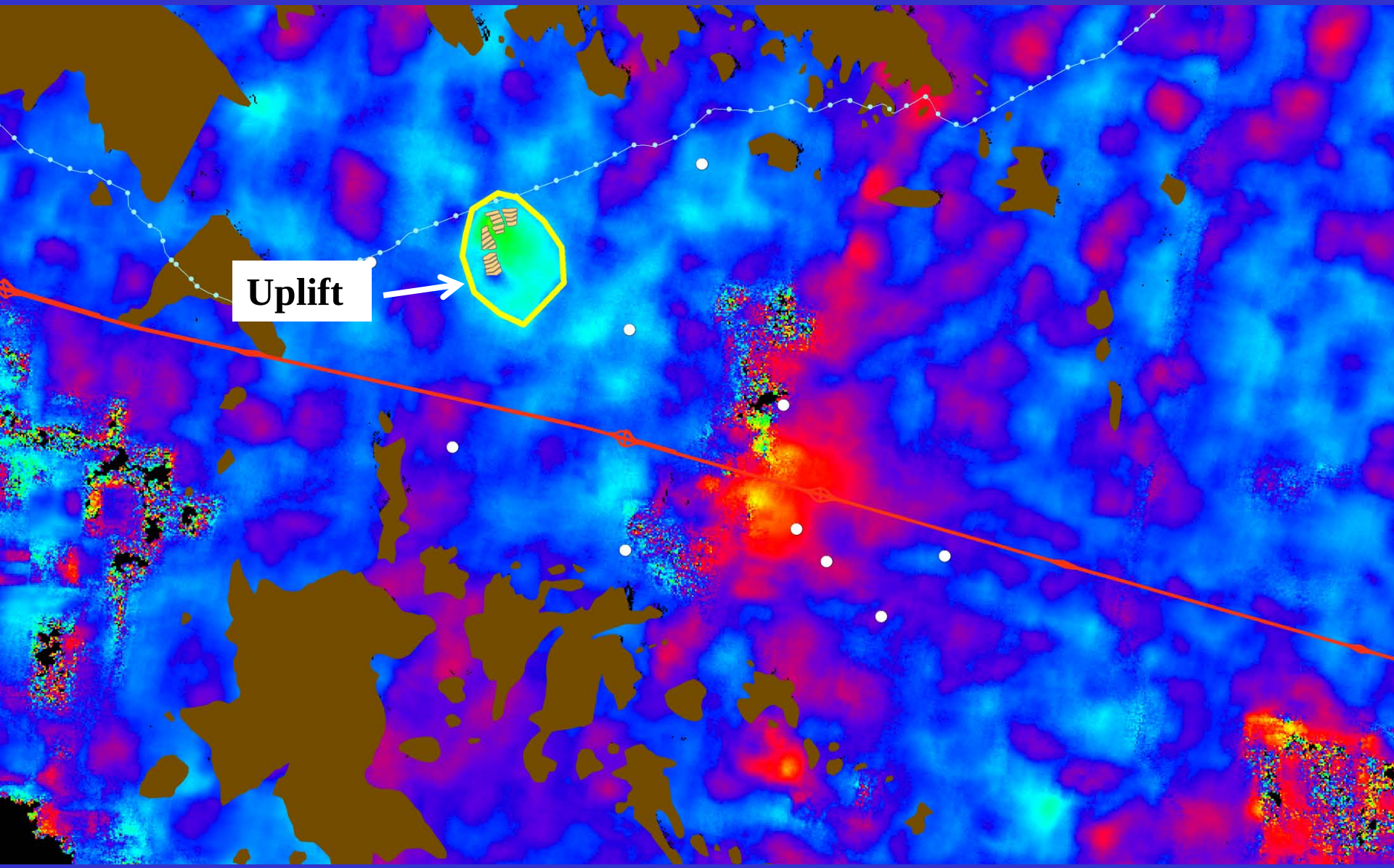


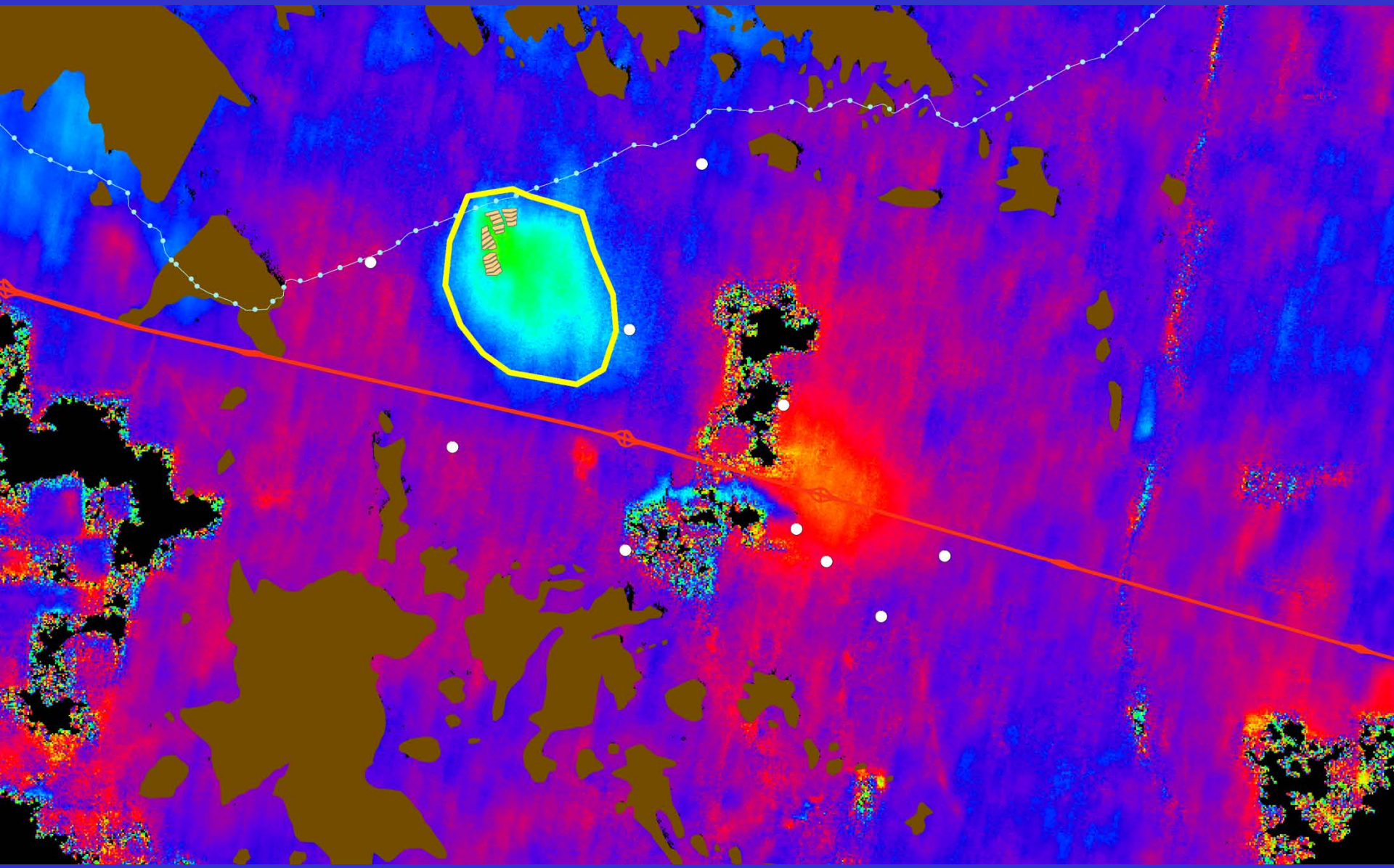
InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 06/10/2006



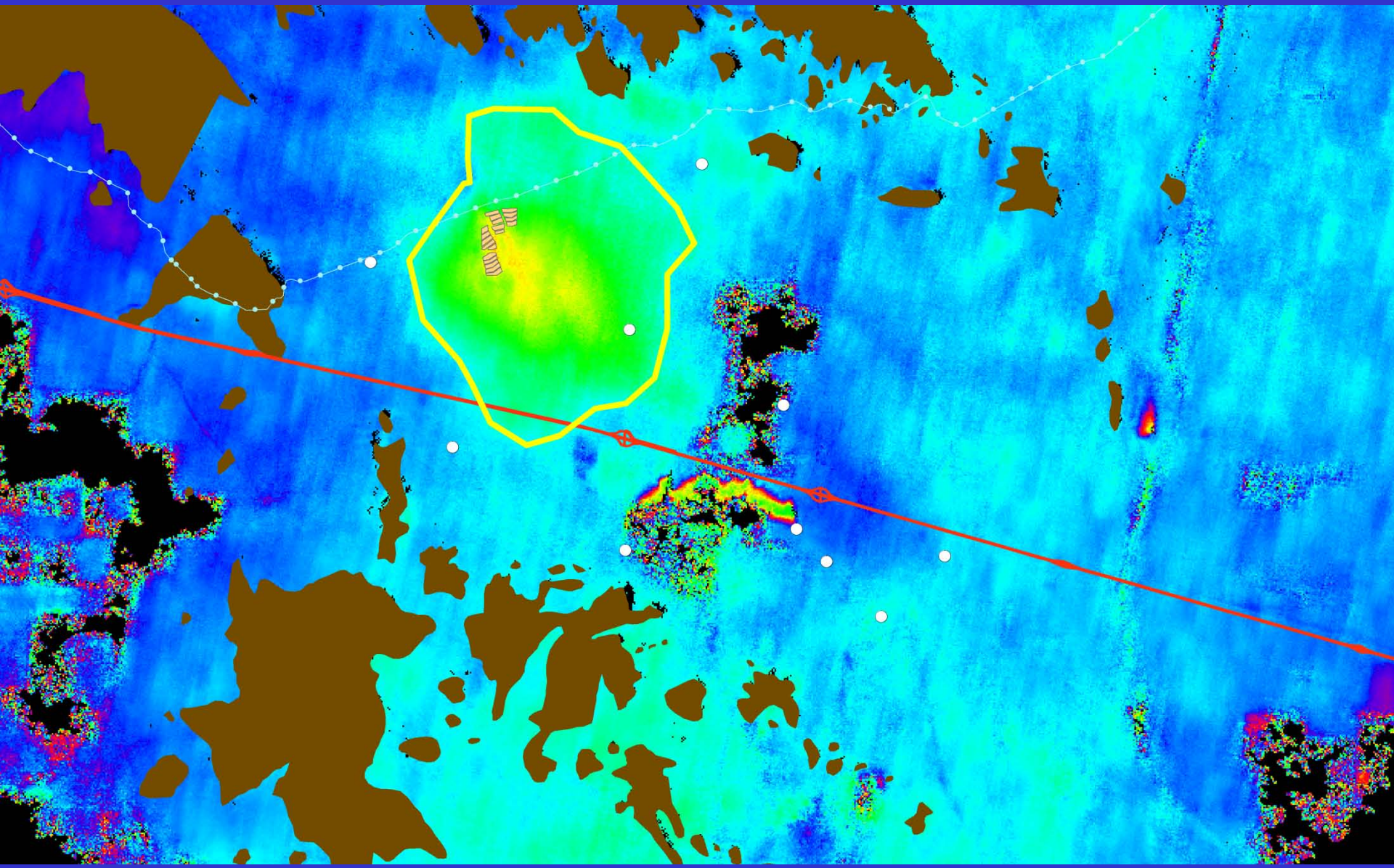
InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 10/28/2006



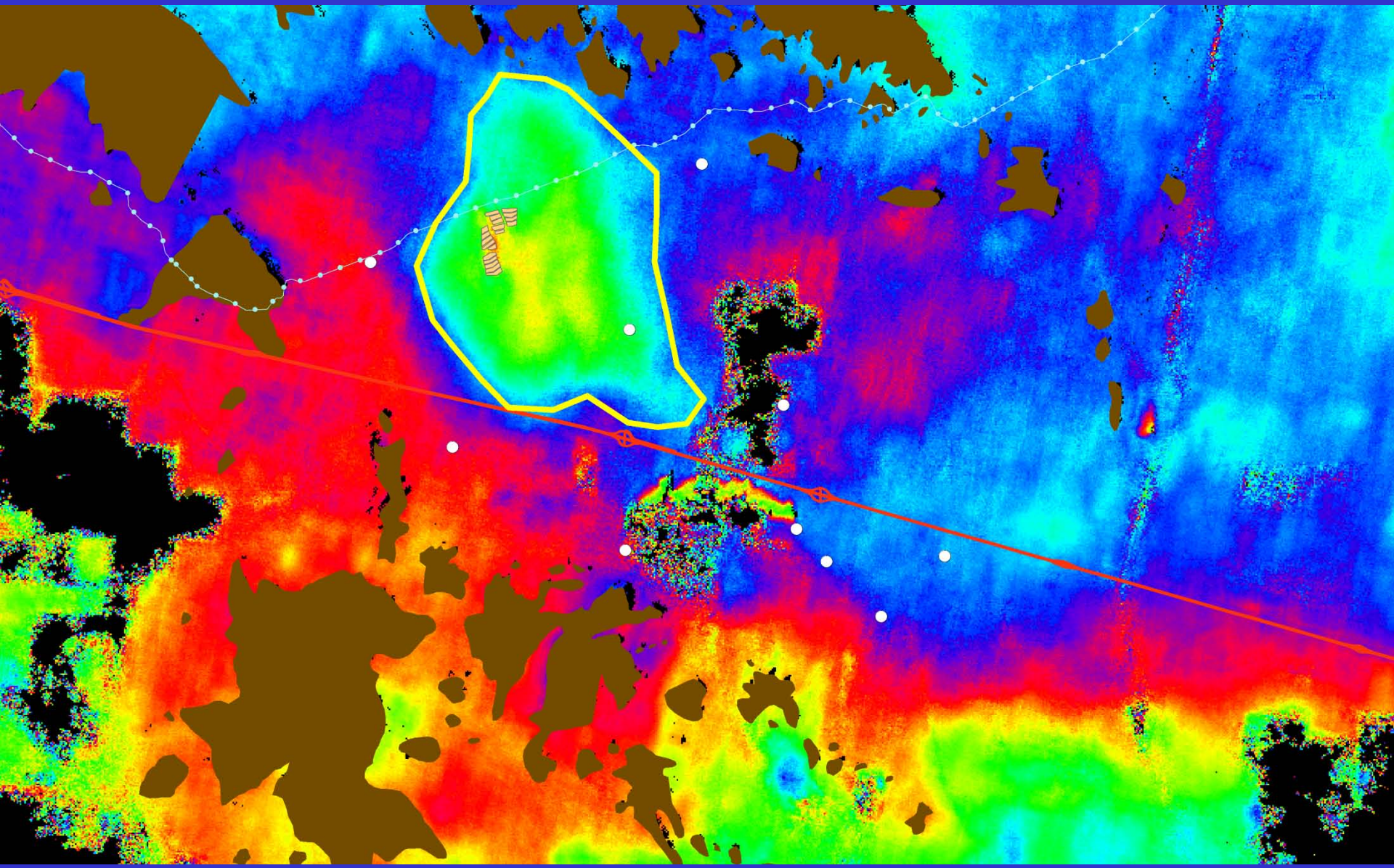
InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 12/02/2006



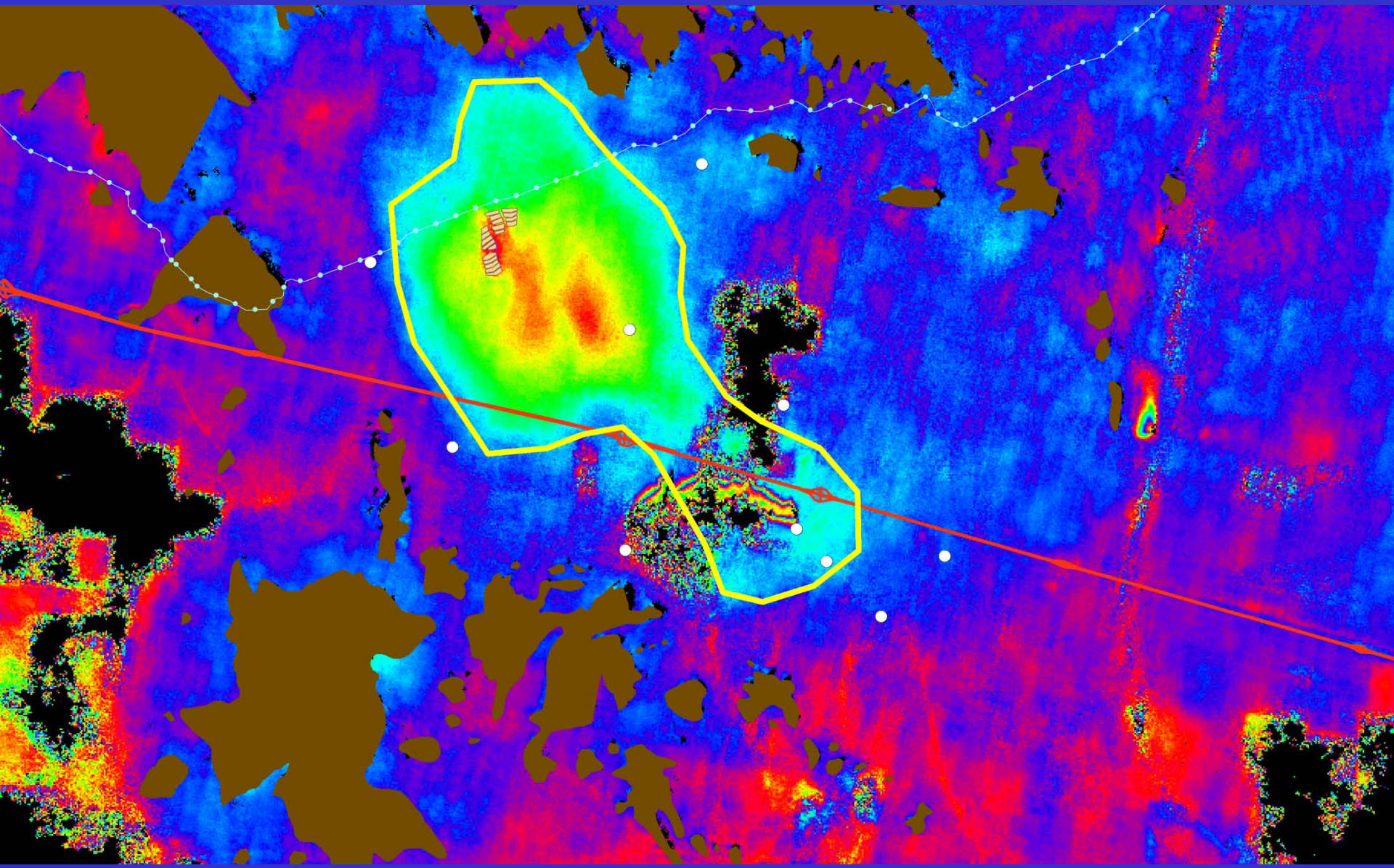
InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 08/04/2007



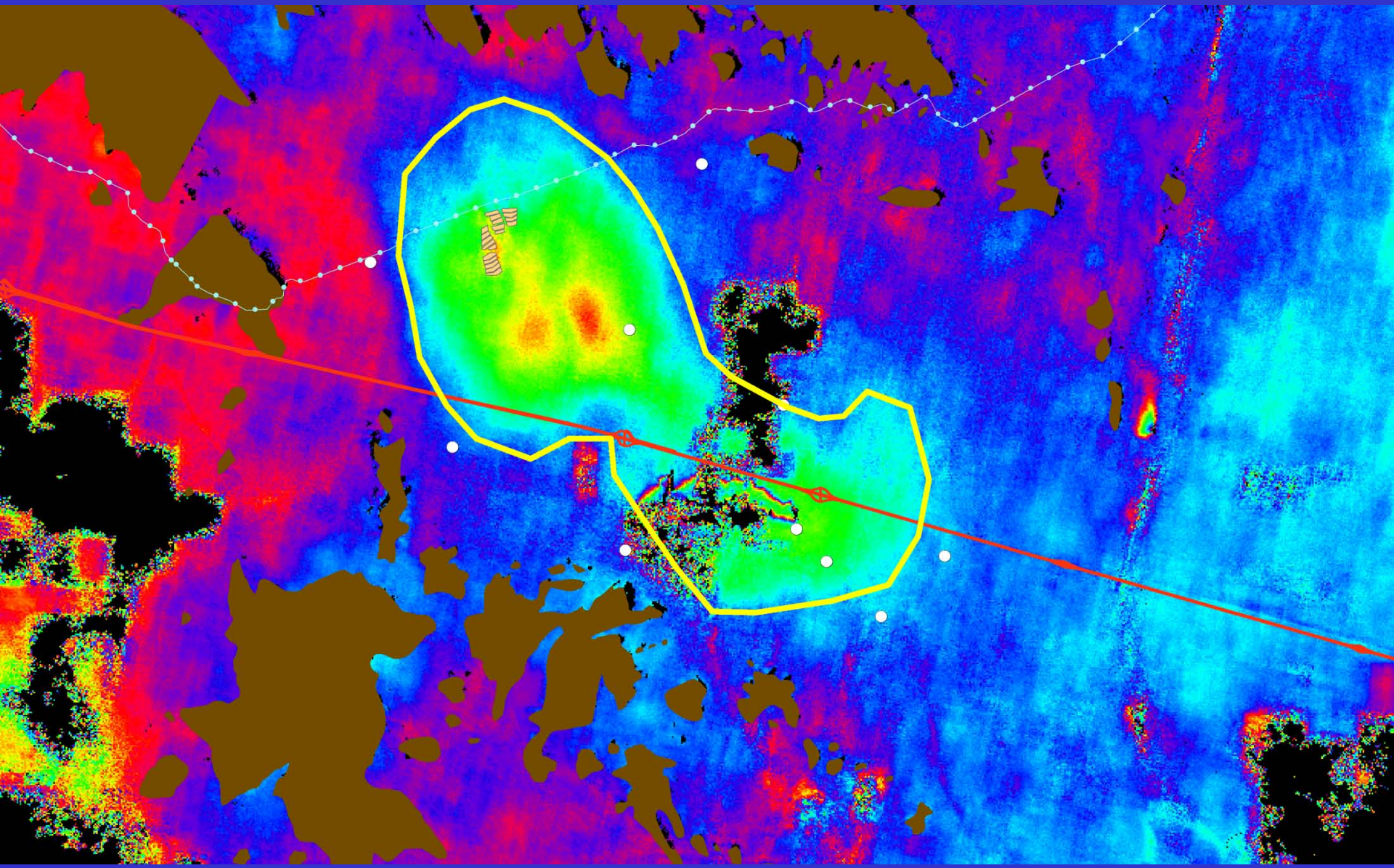
InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 11/17/2007



InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 01/26/2008



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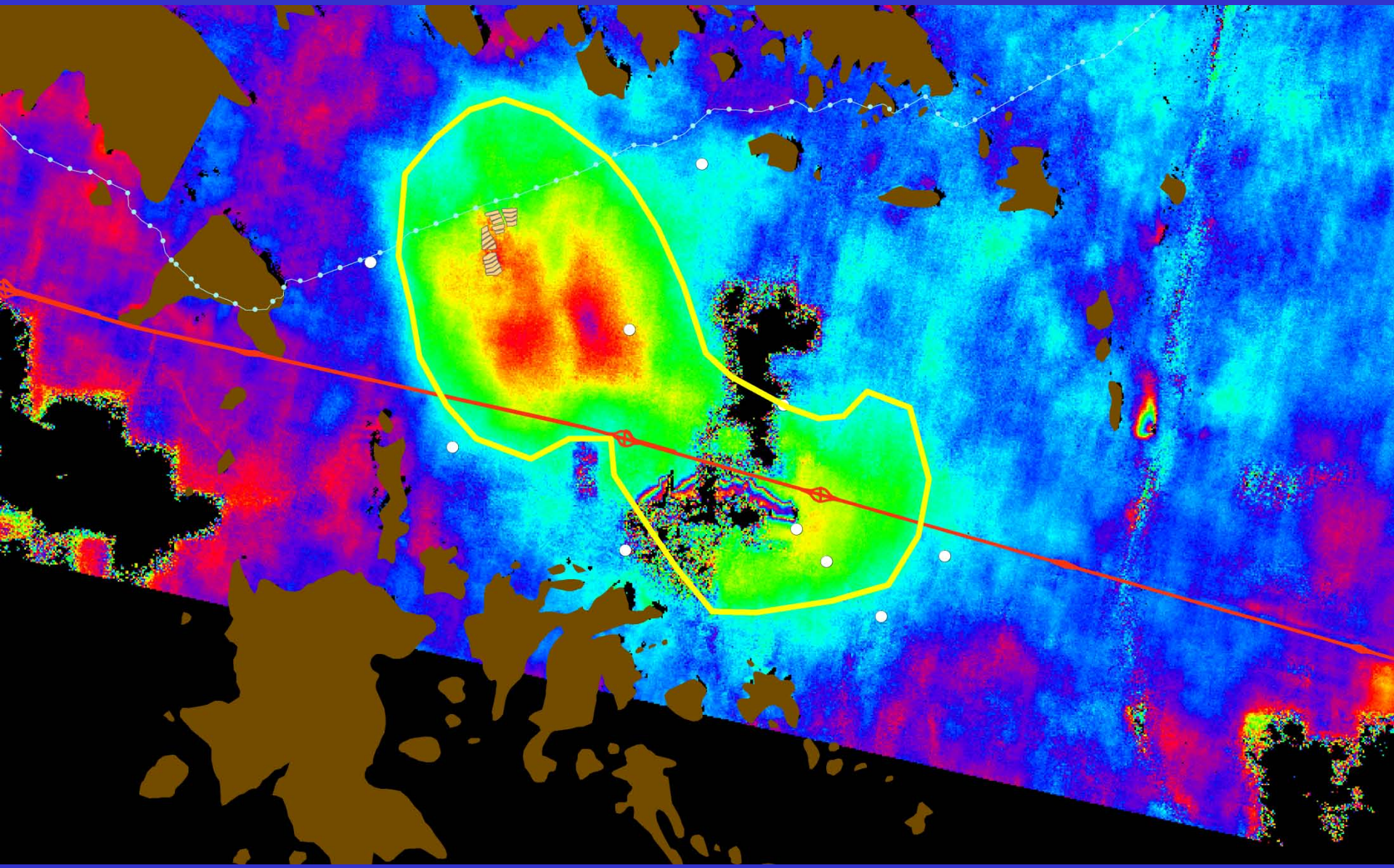
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 04/05/2008



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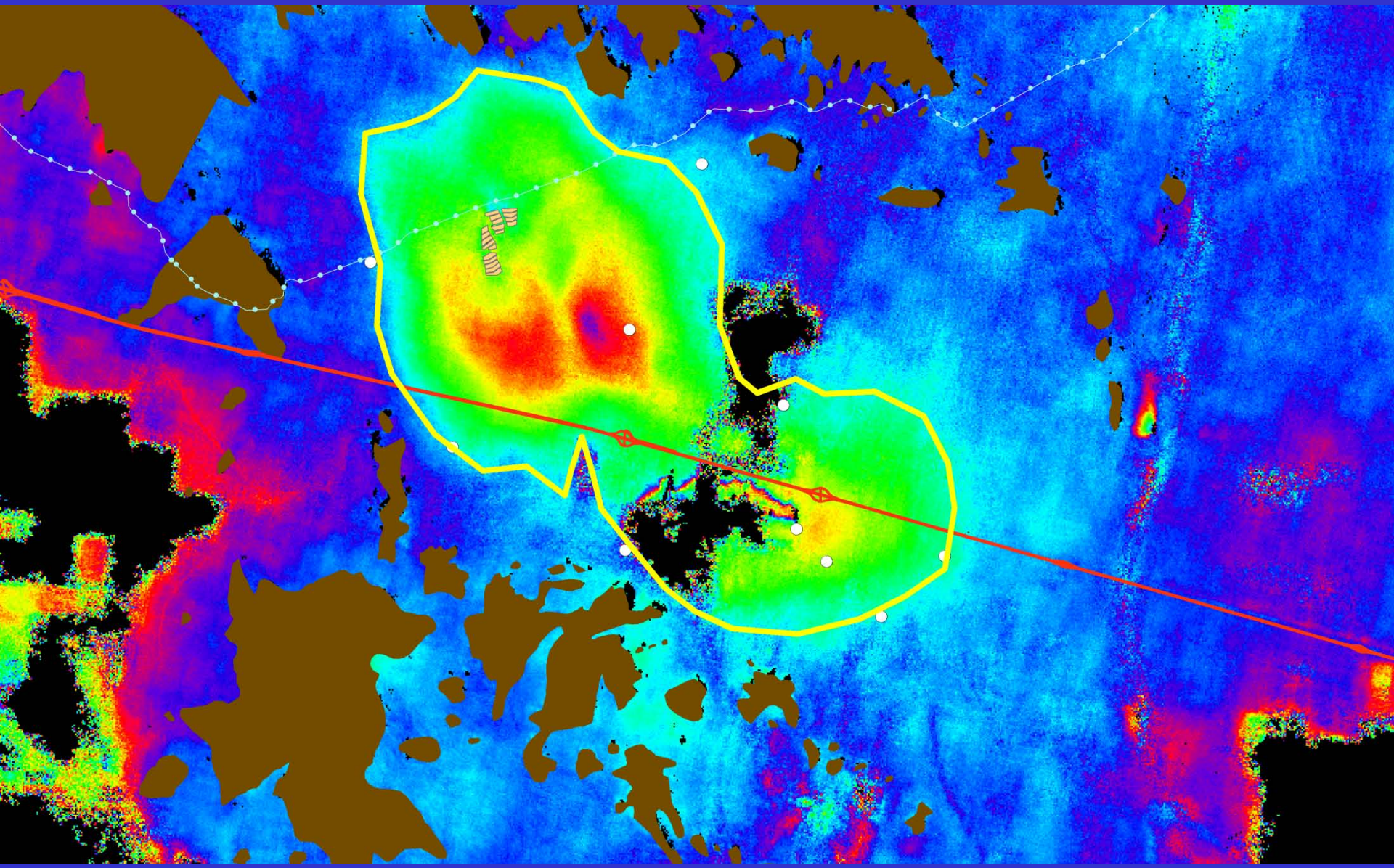
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 11/01/2008



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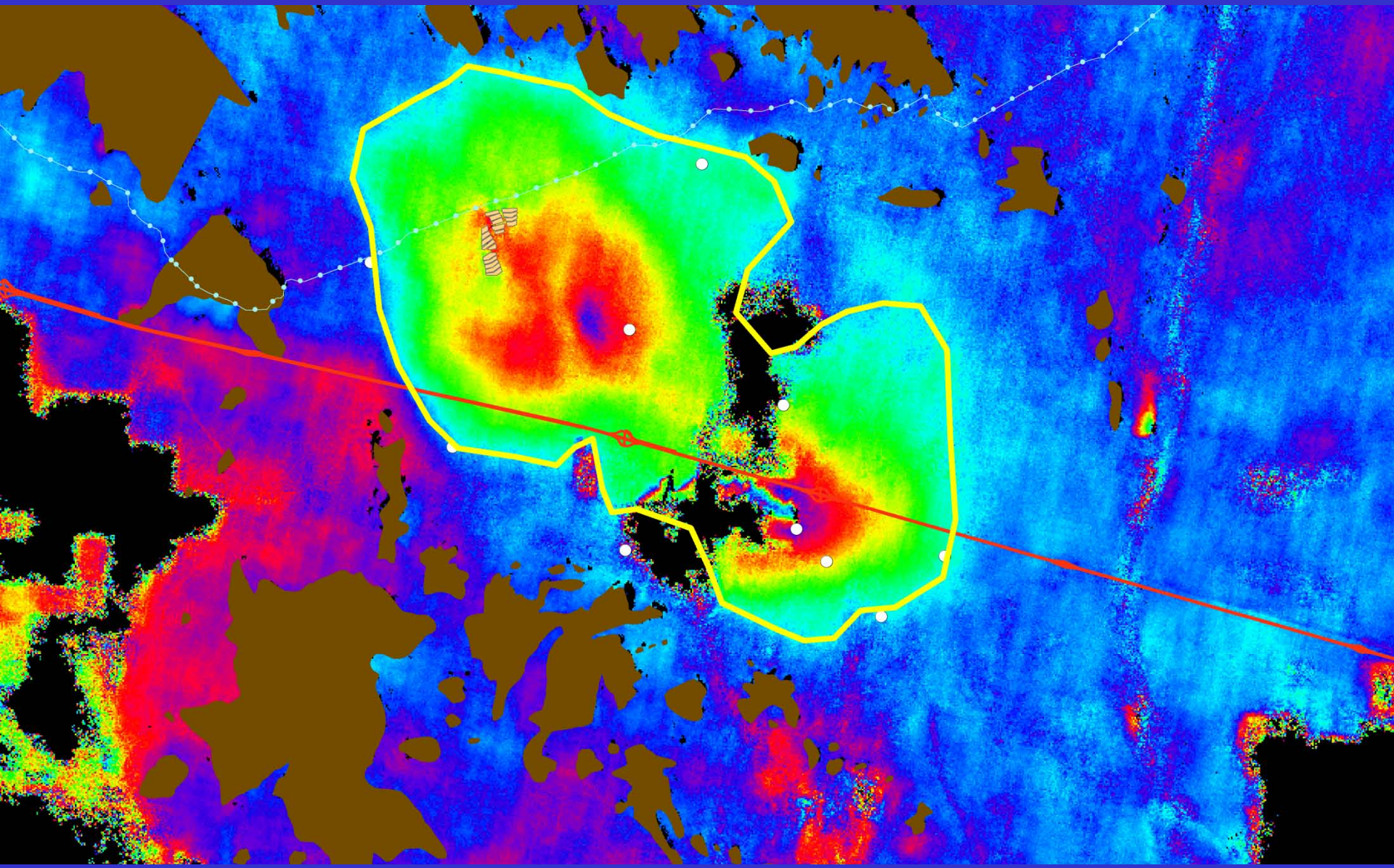
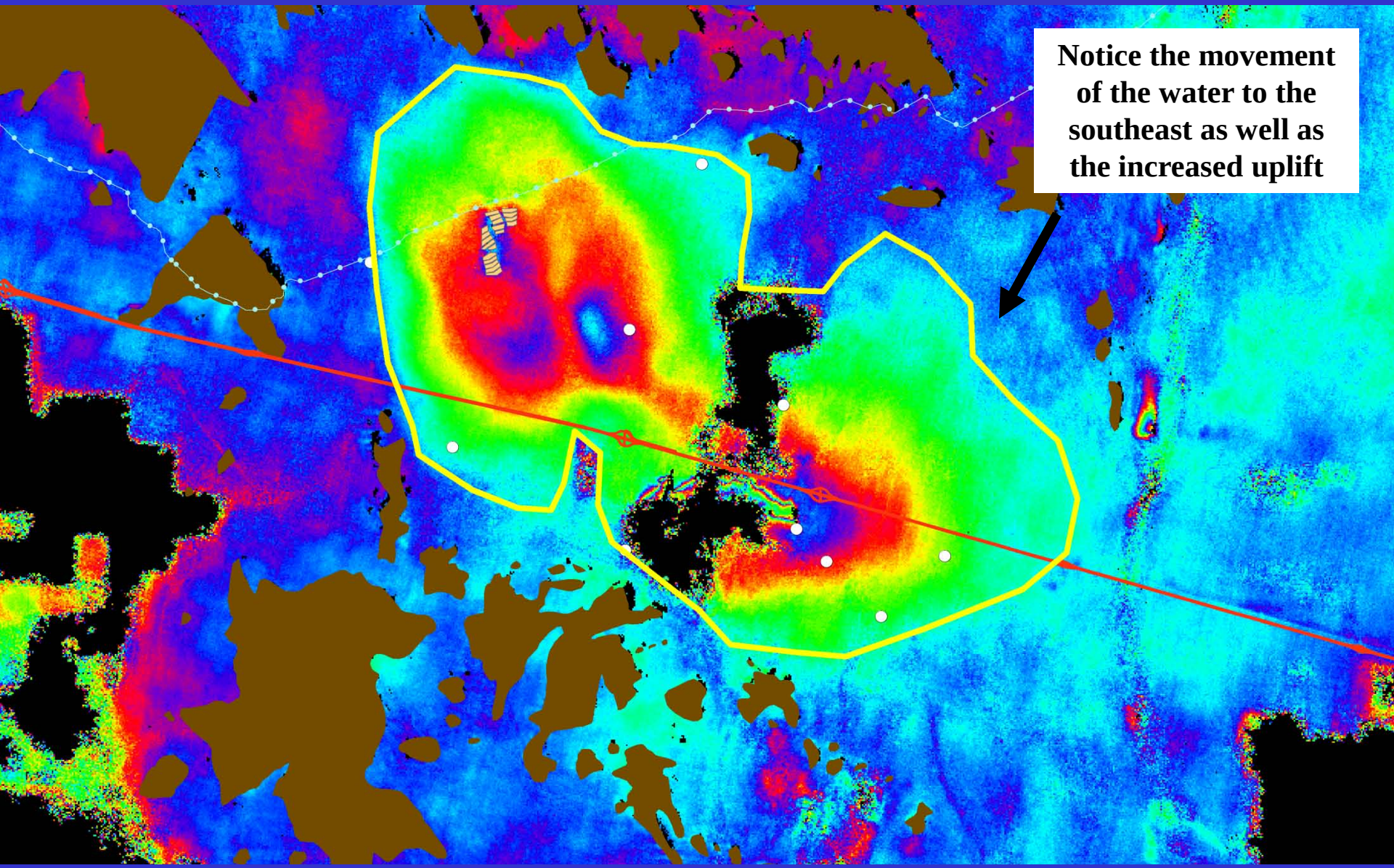
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 01/10/2009



InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 11/21/2009



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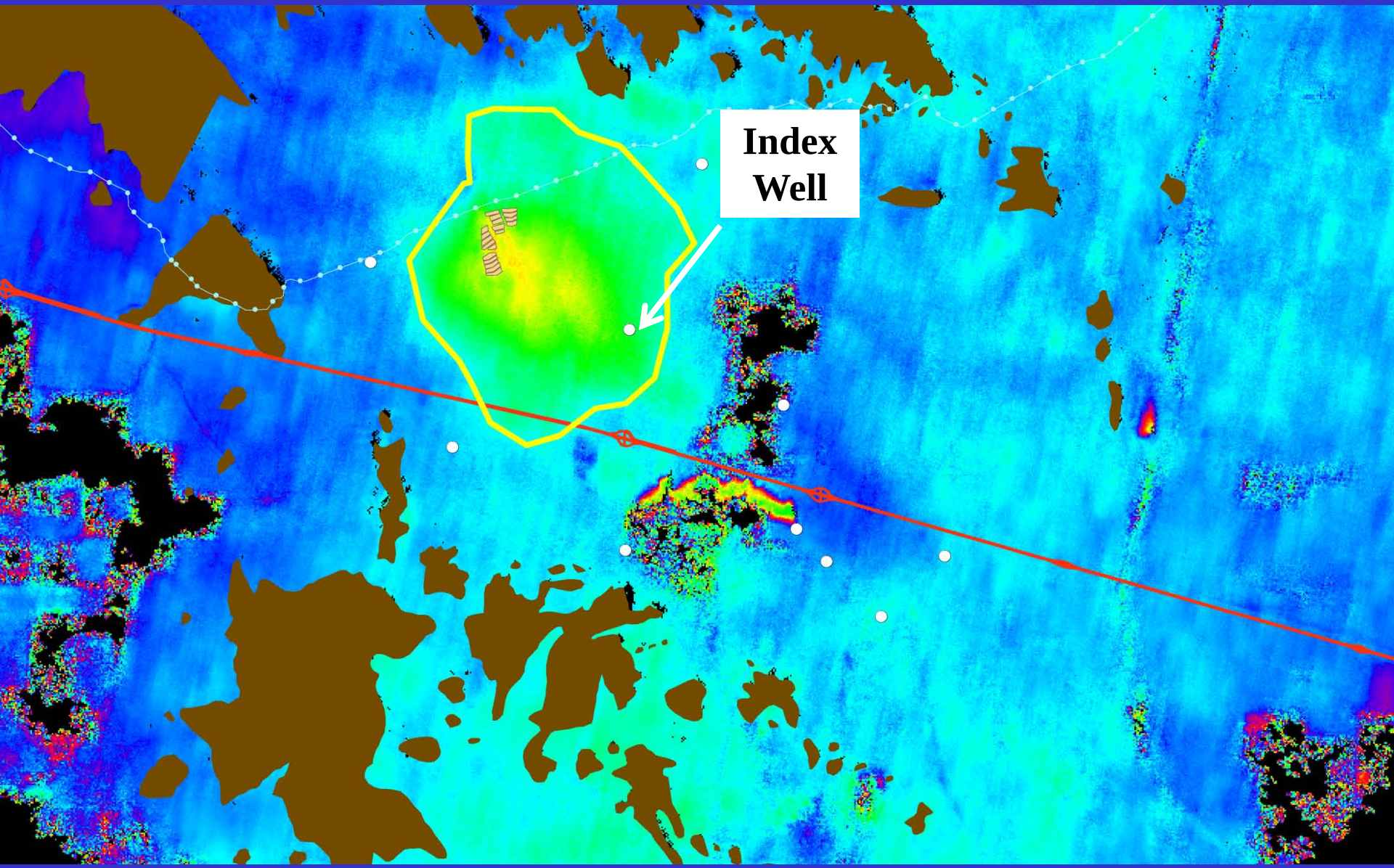
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 12/02/2006



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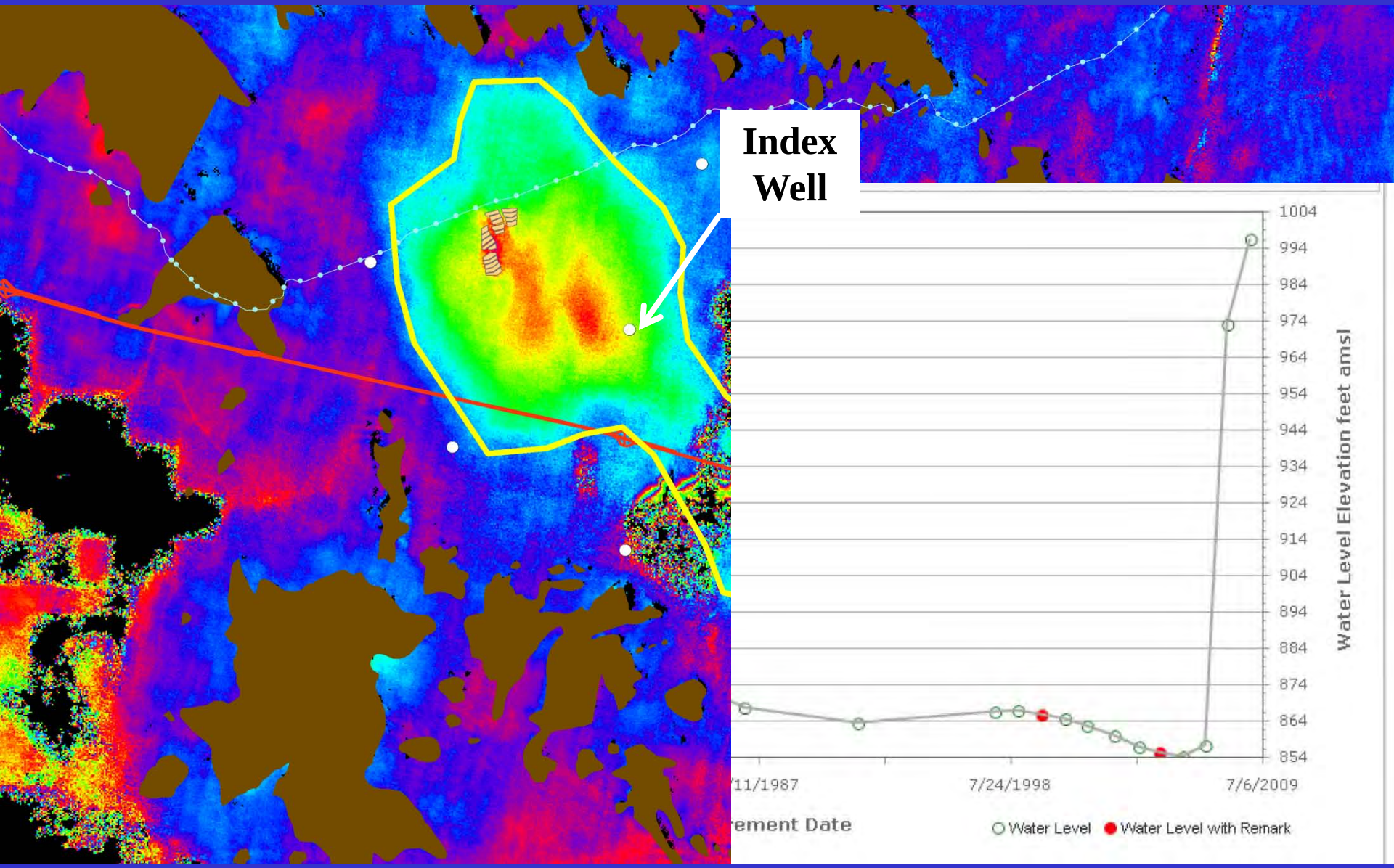
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 11/17/2007



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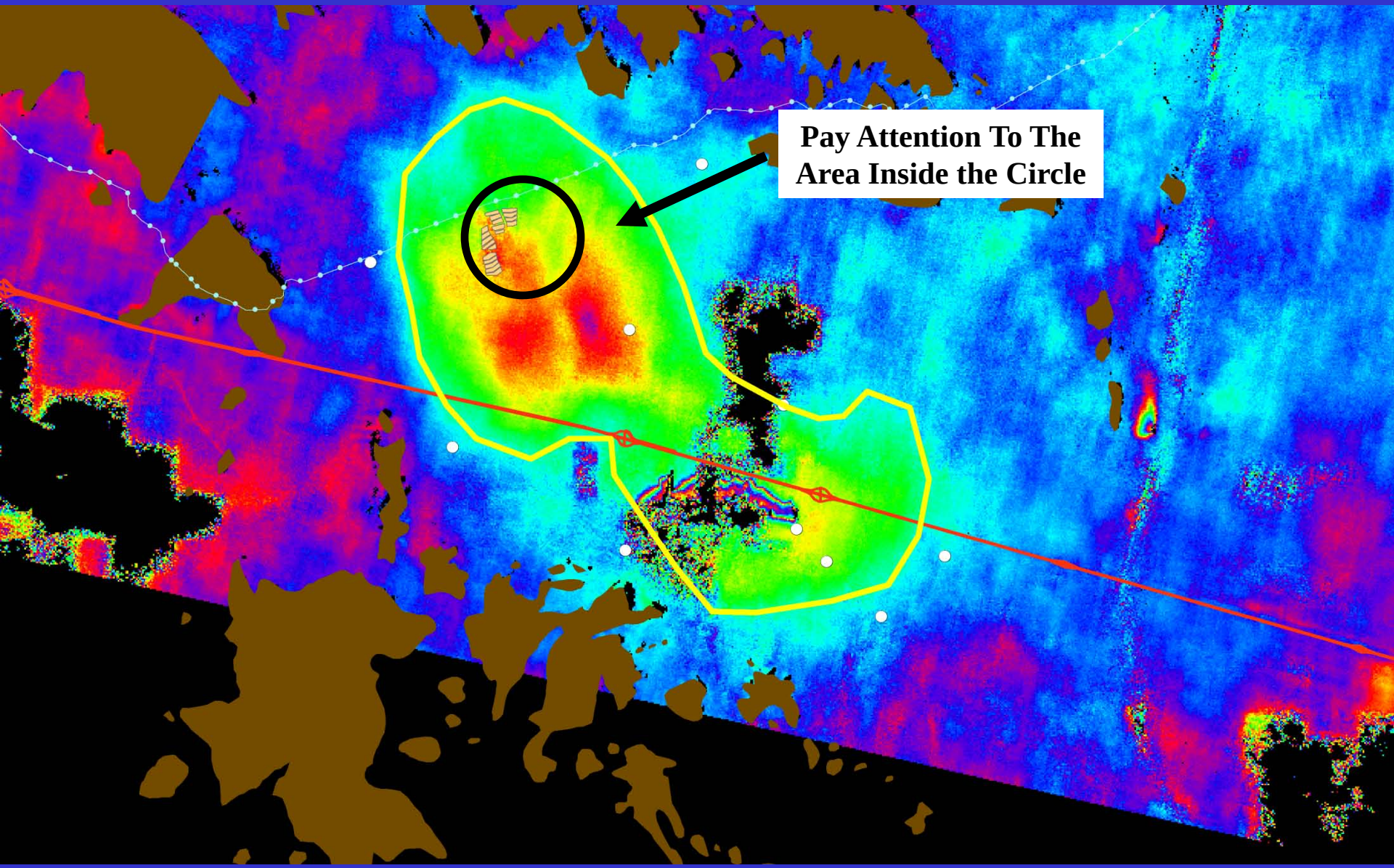
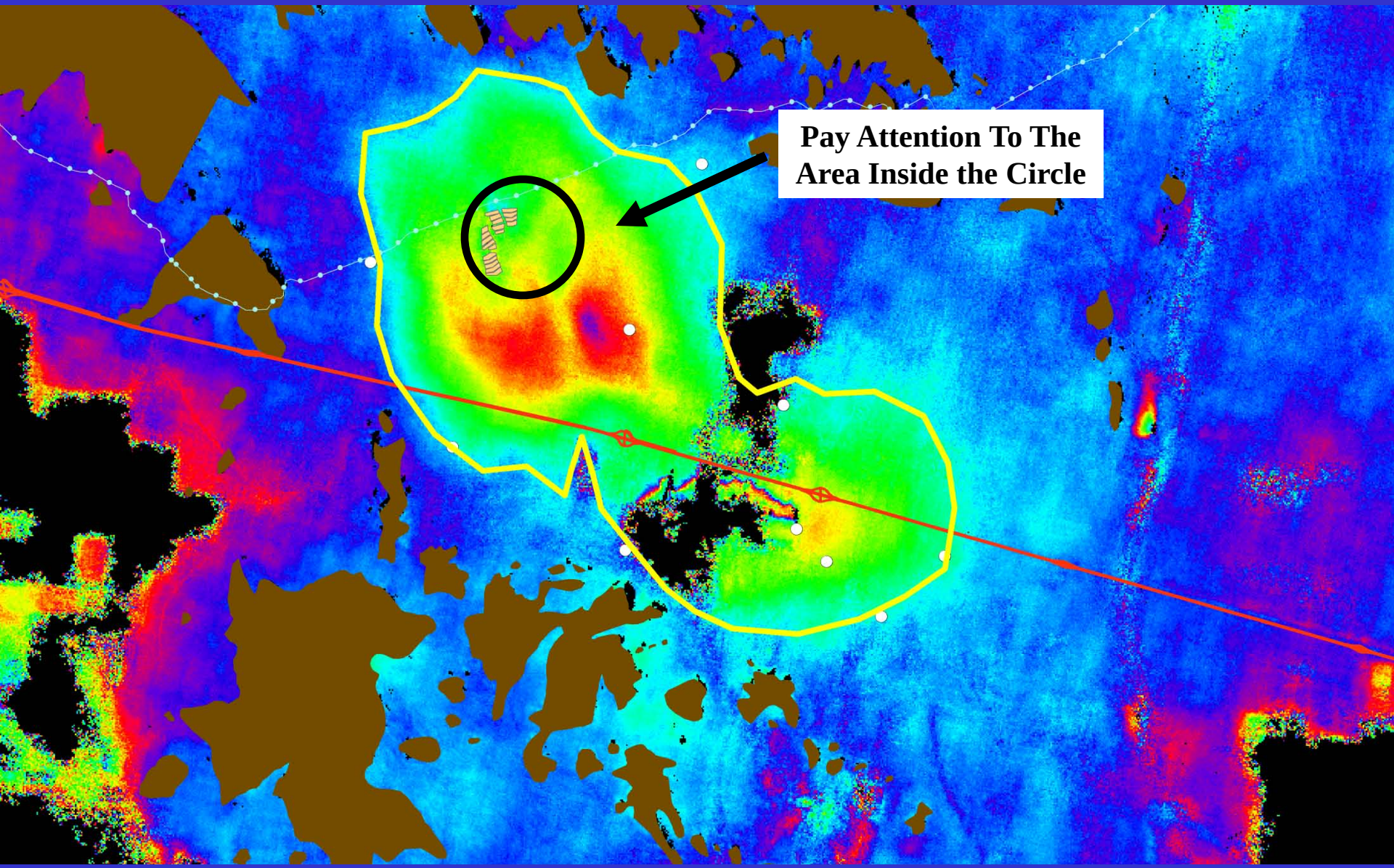
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 04/05/2008



InSAR Used For Monitoring Artificial Recharge and Associated Uplift

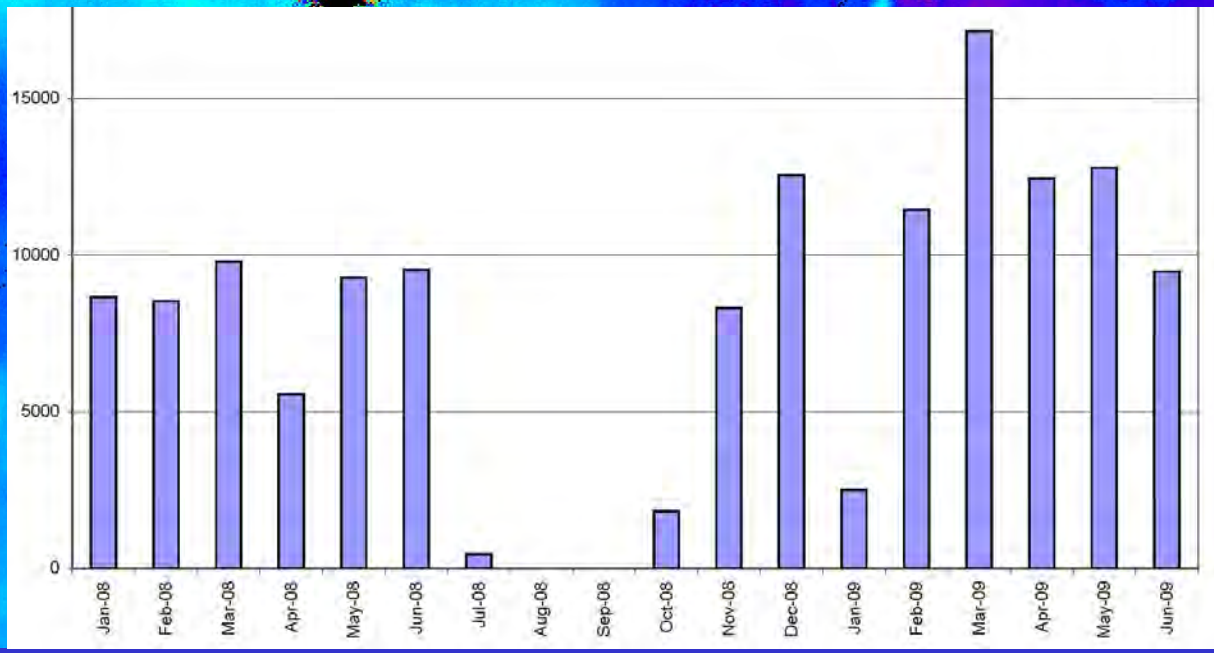
CAP Tonopah Recharge Facility, Tonopah, Maricopa County 11/17/2007 To 11/01/2008

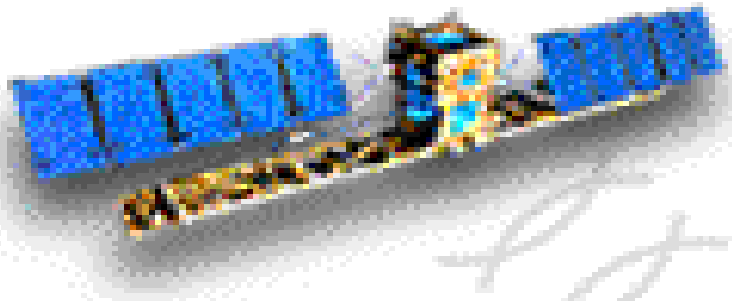


InSAR Used For Monitoring Artificial Recharge and Associated Uplift

CAP Tonopah Recharge Facility, Tonopah, Maricopa County 02/25/2006 To 10/28/2006

Land Subsidence is now occurring. WHY?



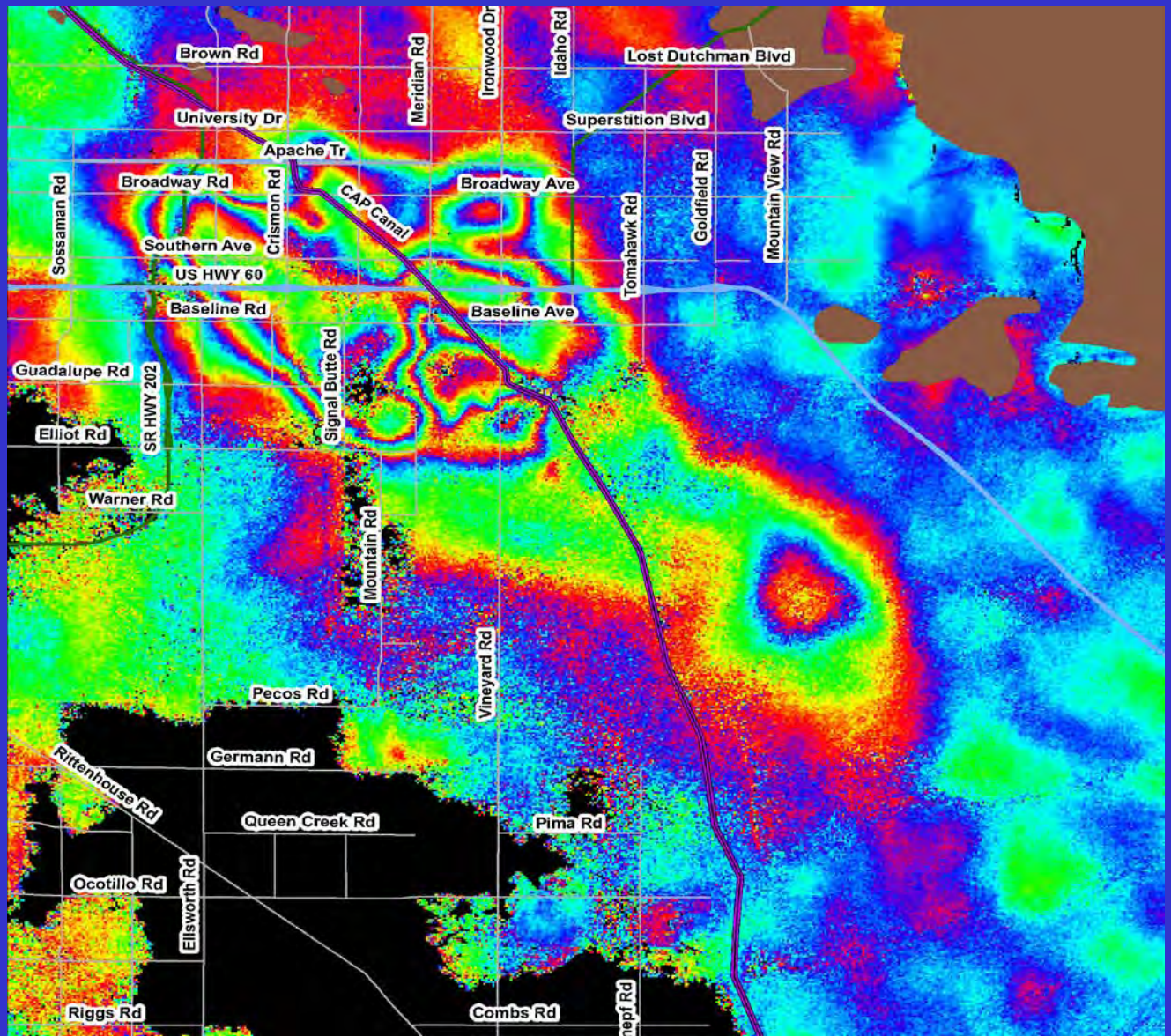


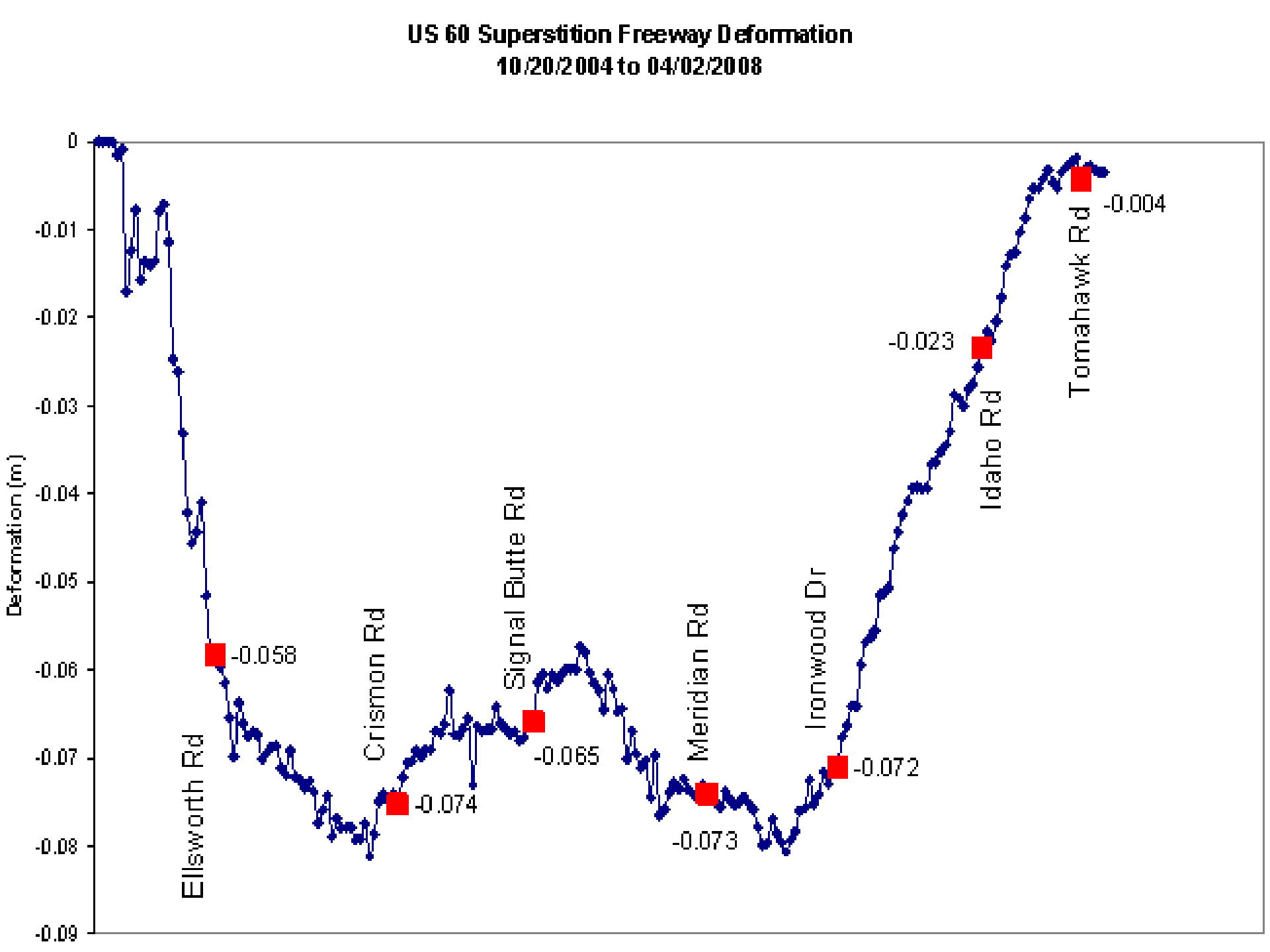
Applications of InSAR

For Land Subsidence Monitoring

3.5 Year Time-Series Interferogram 10/20/2004 To 04/02/2008

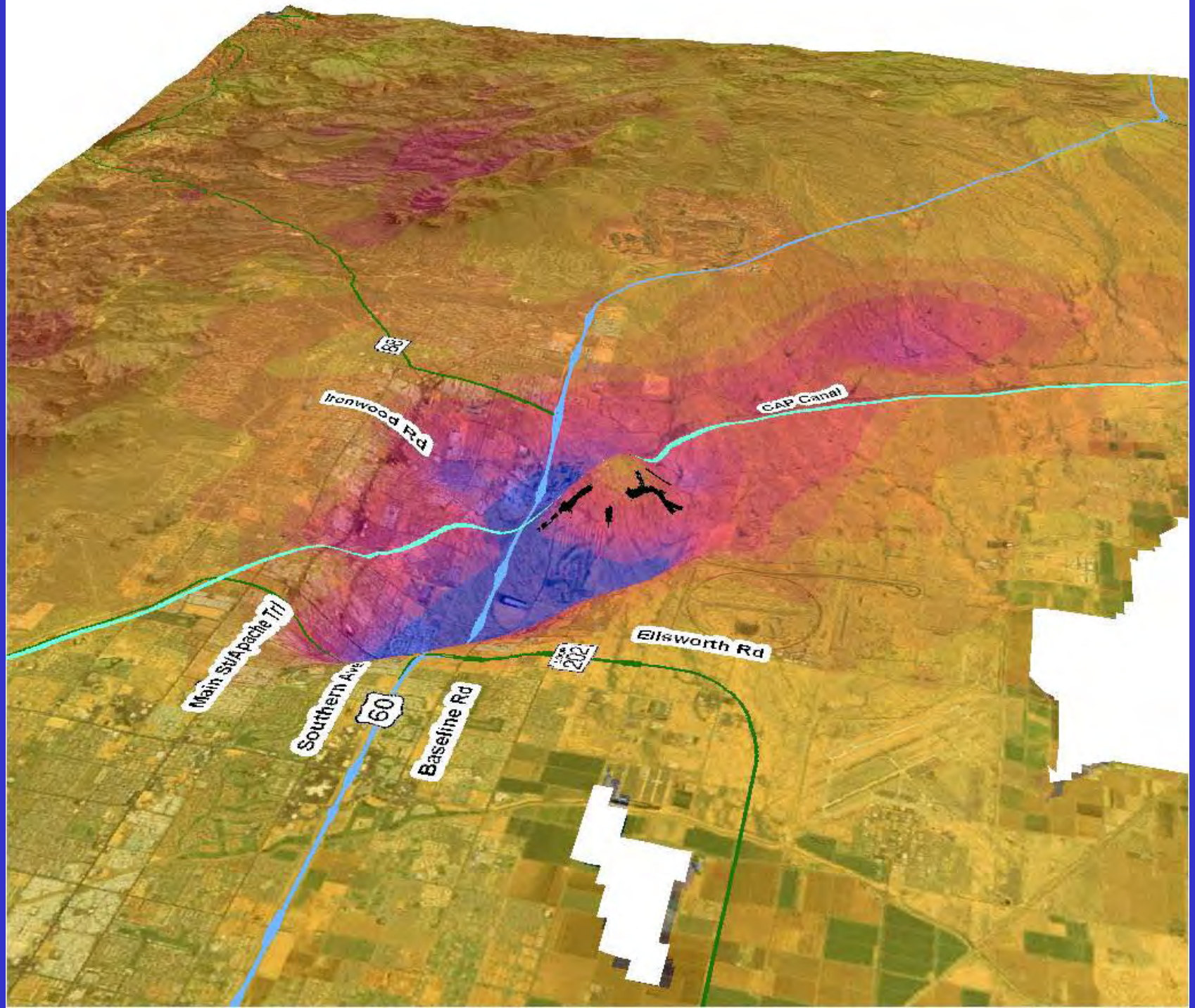
Hawk Rock Land Subsidence Feature in East Mesa/Apache Junction Area, Maricopa/Pinal Counties

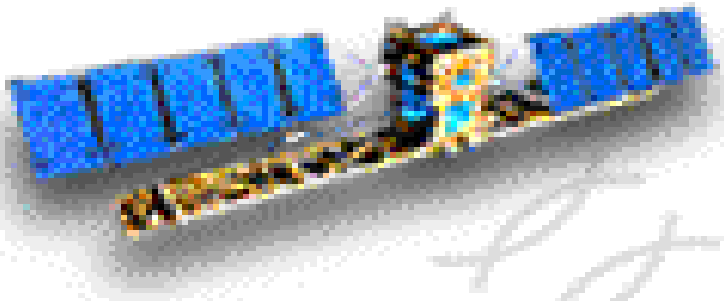



US 60 Superstition Freeway Deformation
10/20/2004 to 04/02/2008
Deformation (m)
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
Ellsworth Rd
-0.058
Crismon Rd
-0.074
Signal Butte Rd
-0.065
Meridian Rd
-0.073
Ironwood Dr
-0.072
Idaho Rd
-0.023
Tomahawk Rd
-0.004

Enhanced 3D View

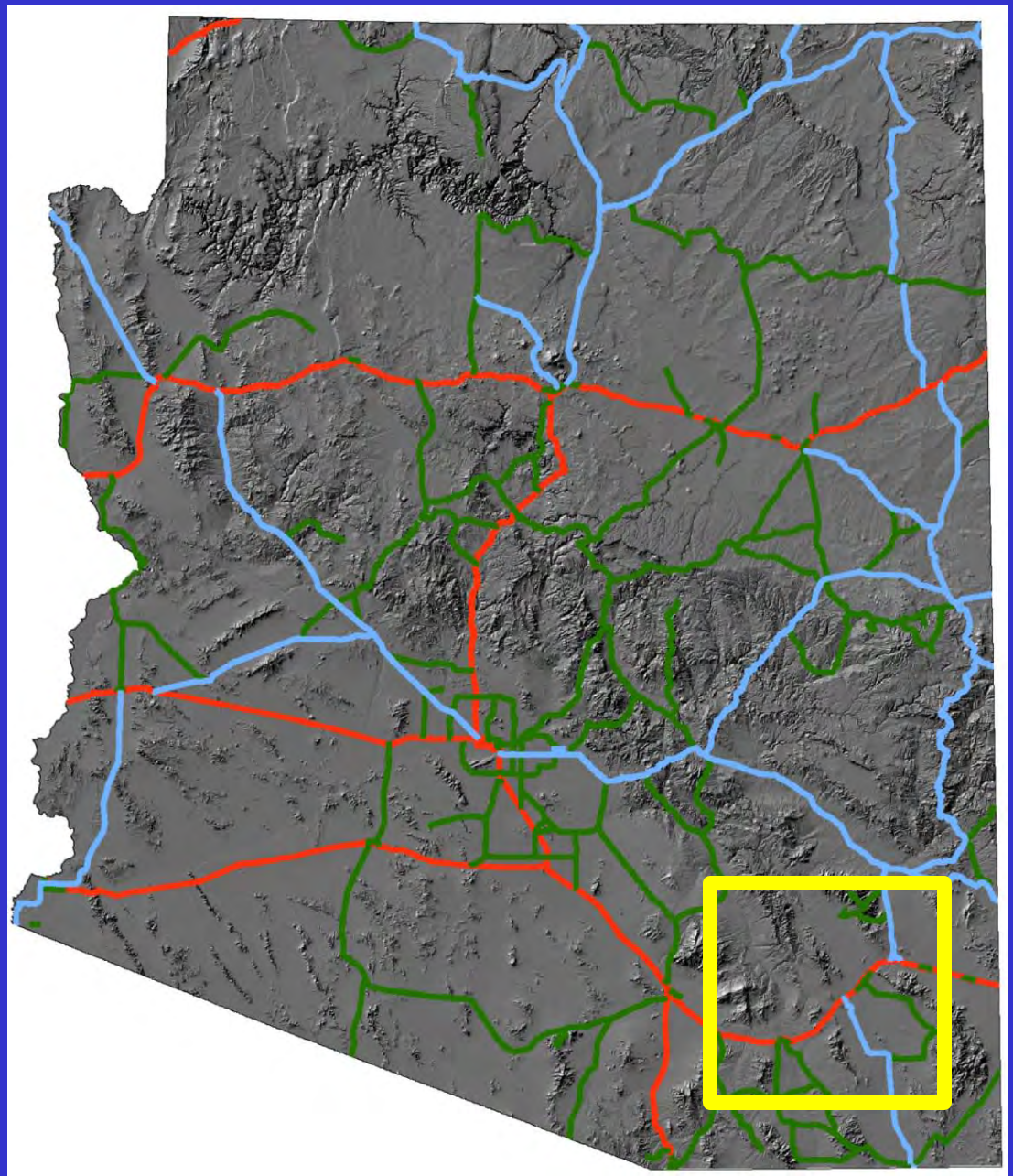
Land Subsidence for the Hawk Rock Area in Eastern Maricopa and Western Pinal Counties


Ironwood Rd
CAP Canal
Ellsworth Rd
Main St/Apache Trl
Southern Ave
Baseline Rd
60
202

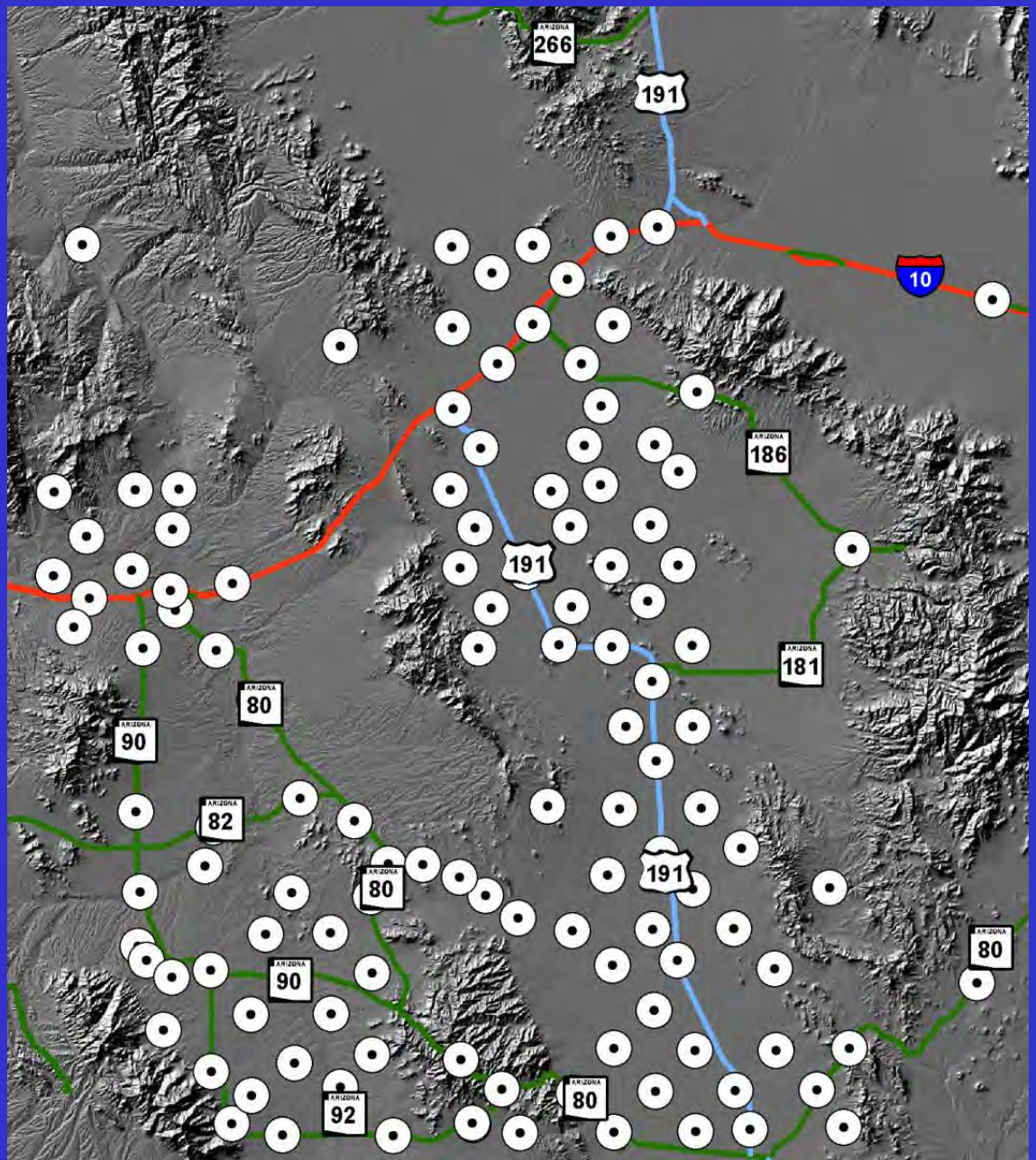


Why A Surveyor Should Know Where Land Subsidence is Occurring?

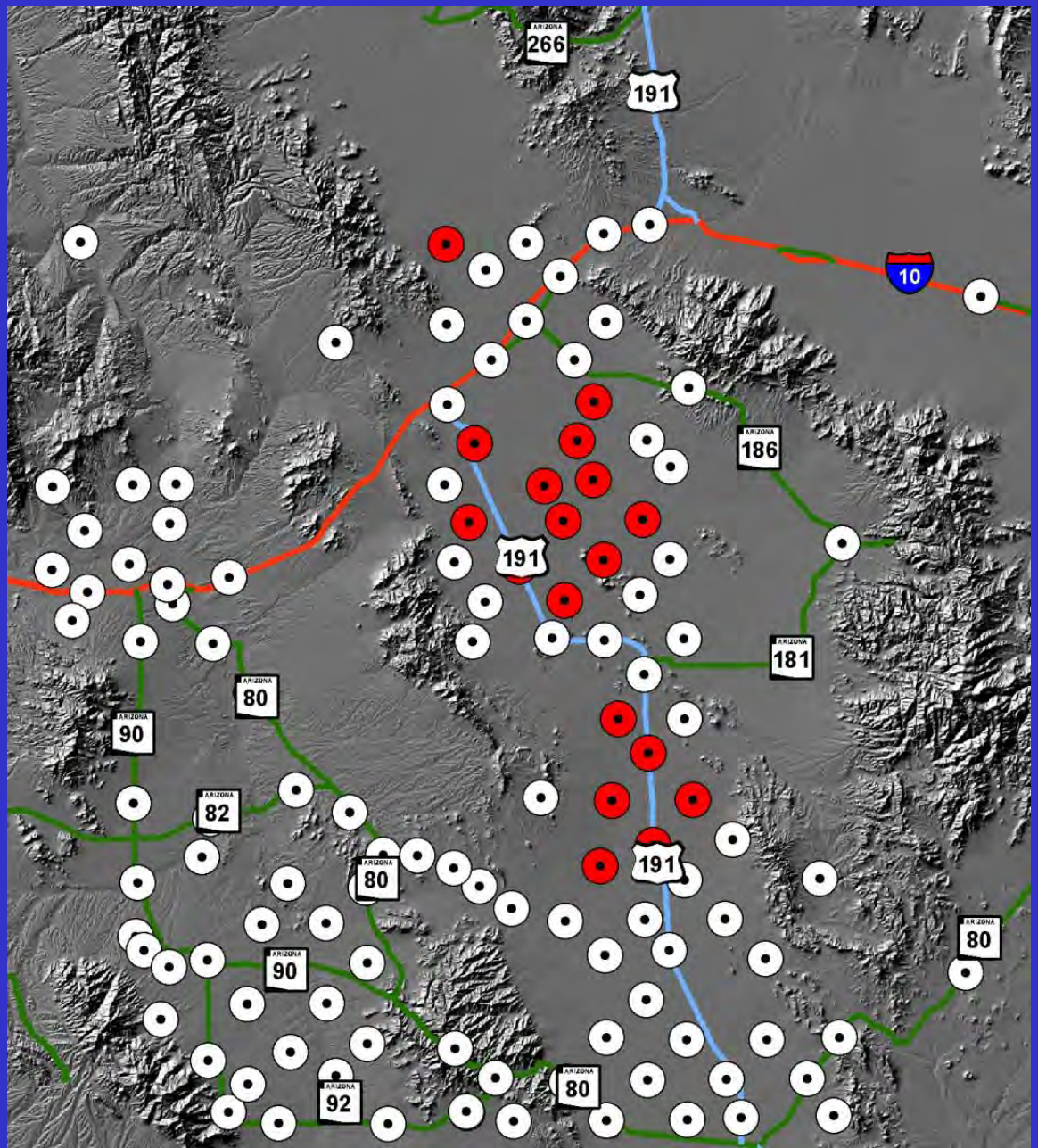
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Cochise County Survey Control



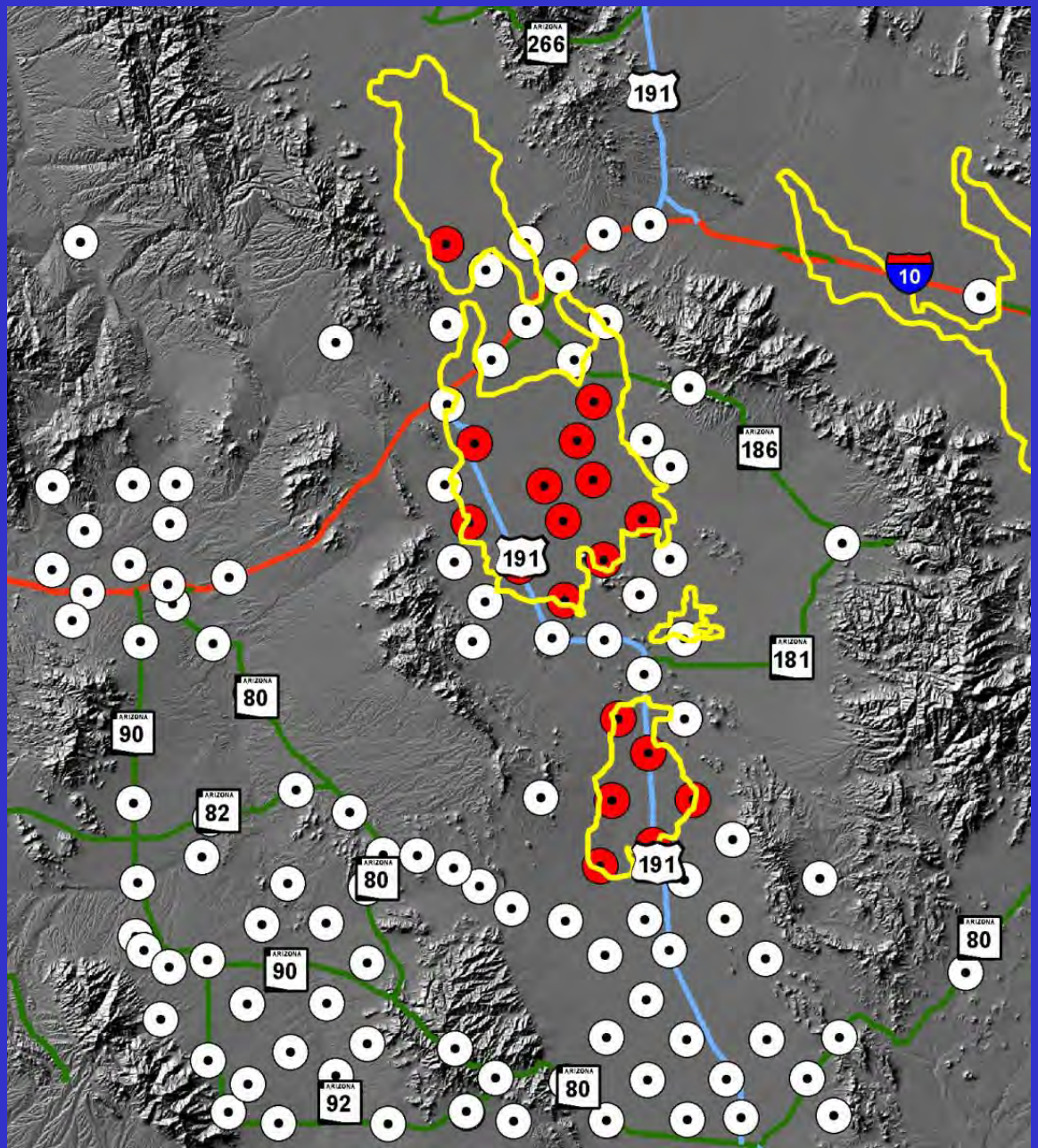
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Cochise County Survey Control (White Dots)



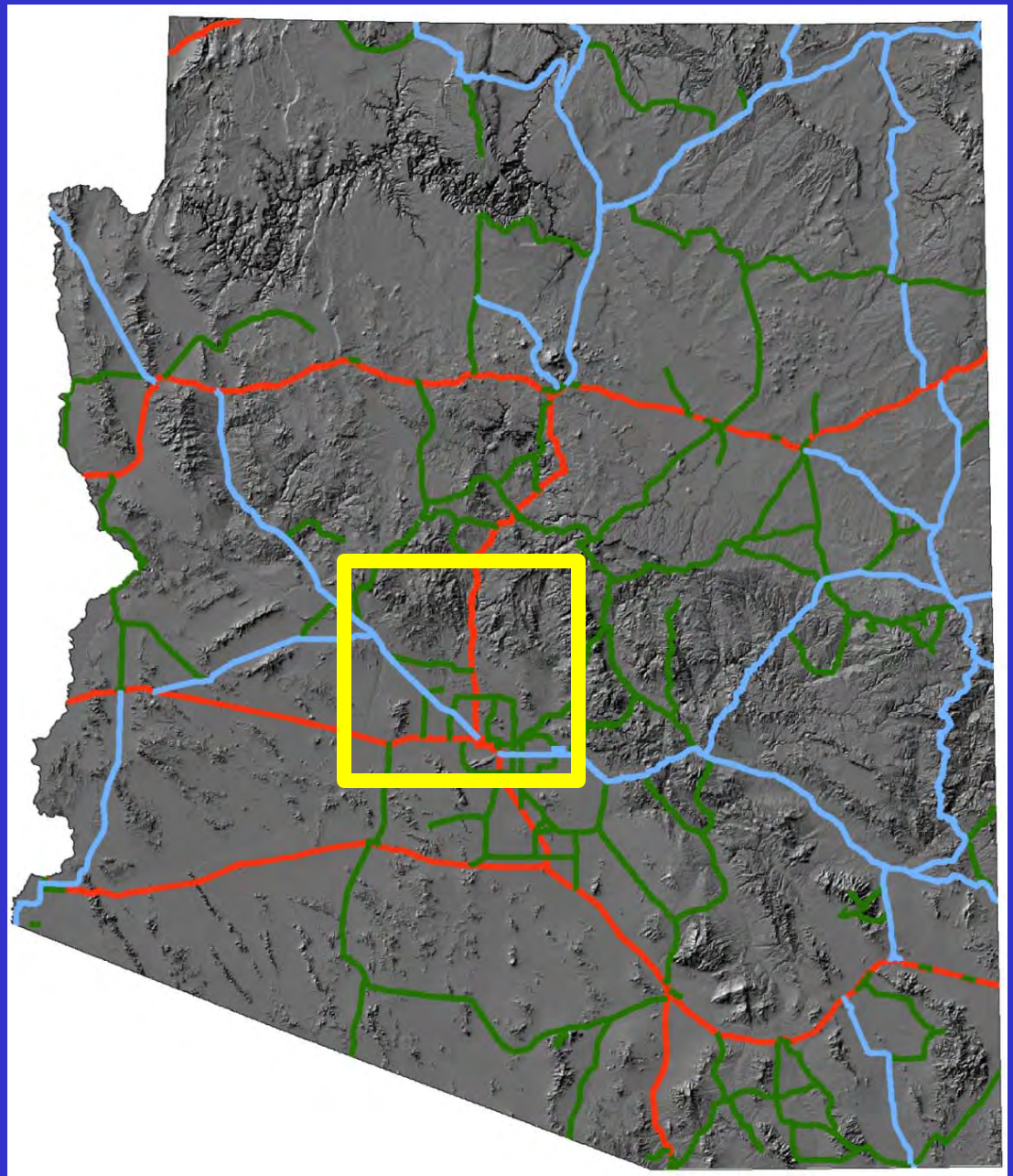
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Cochise County Survey Control Affected By Land Subsidence (Red Dots)



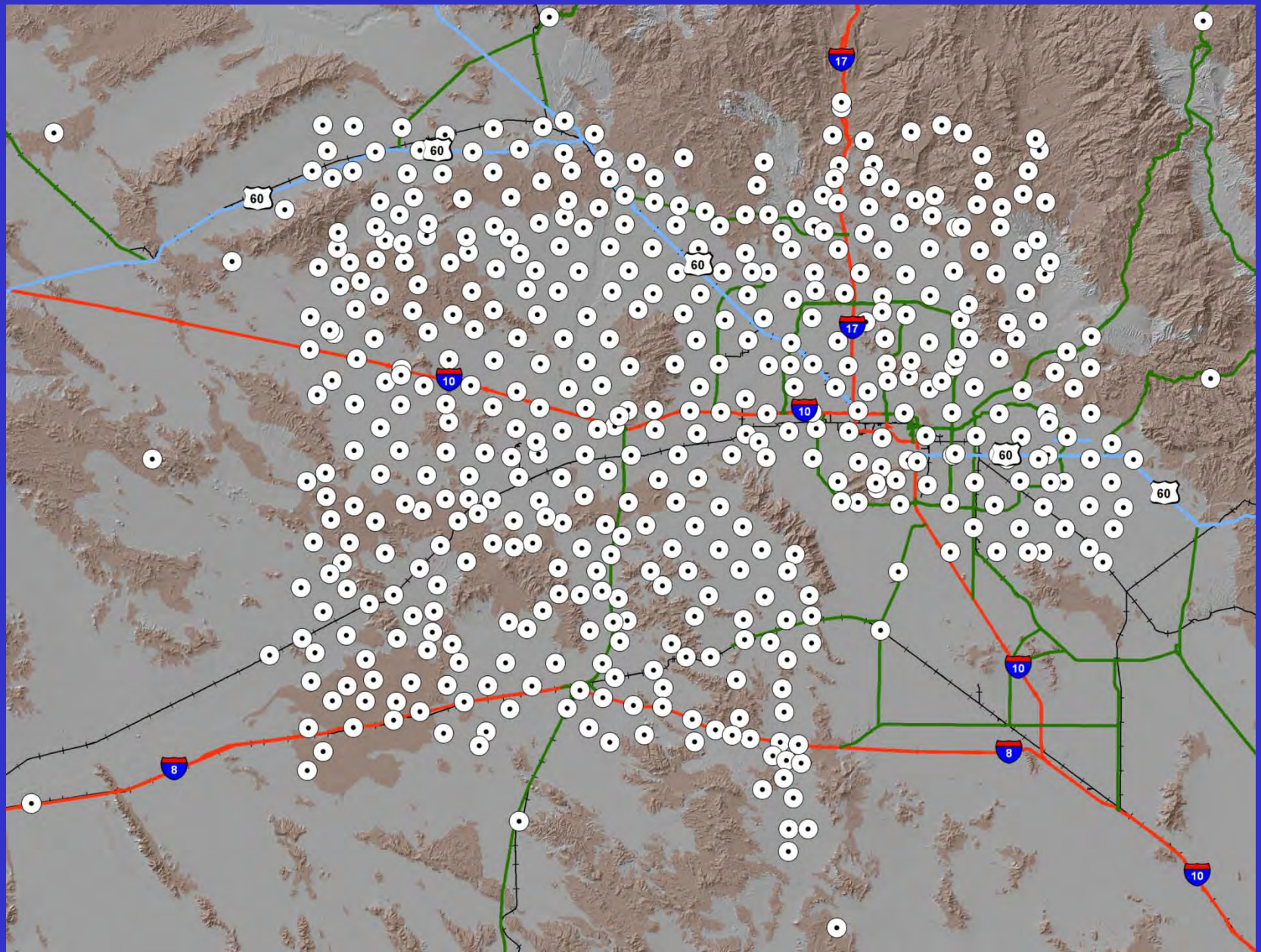
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Cochise County Survey Control Affected By Land Subsidence (Red Dots)



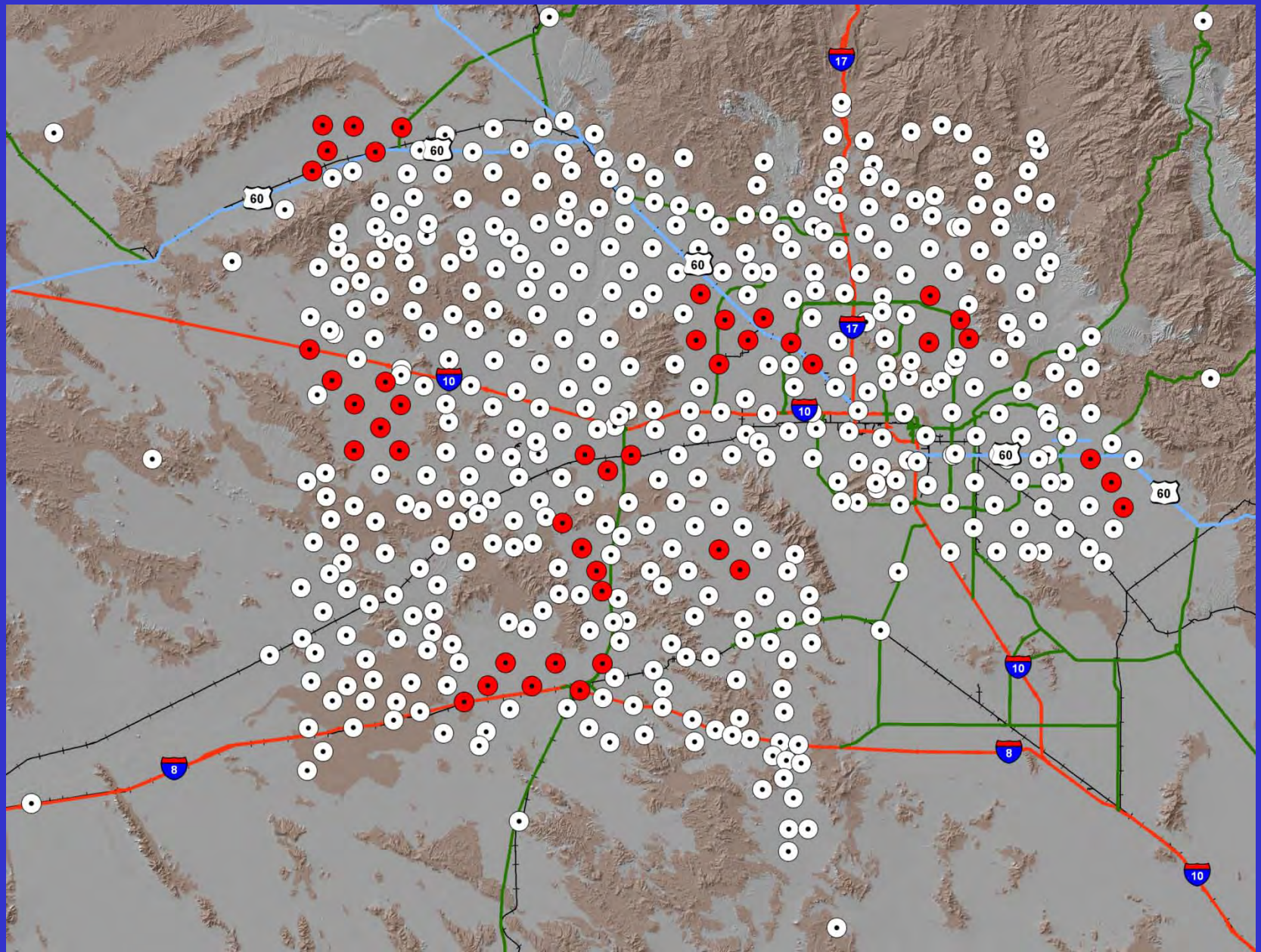
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Maricopa County Survey Control



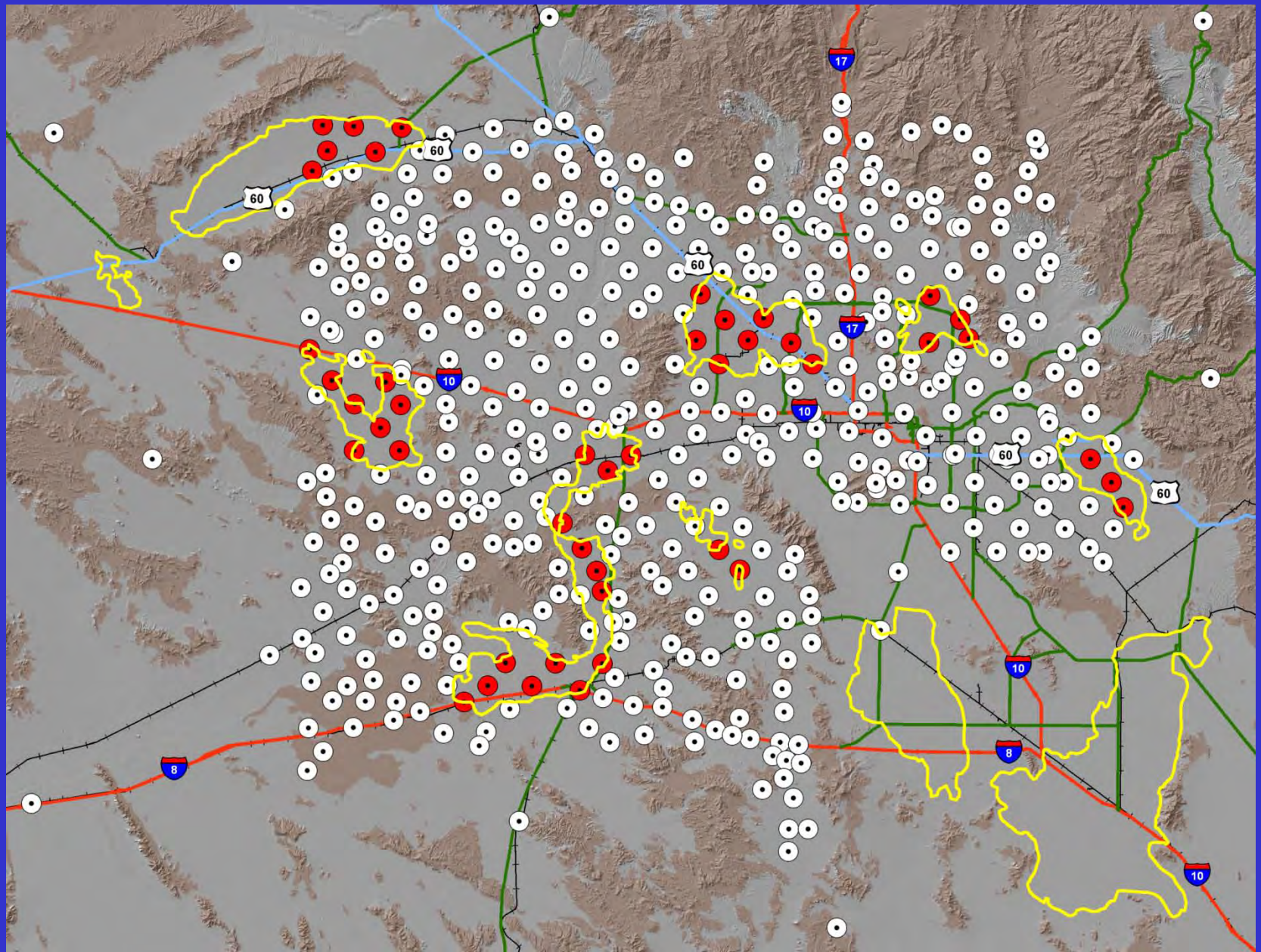
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Maricopa County Survey Control (White Dots)



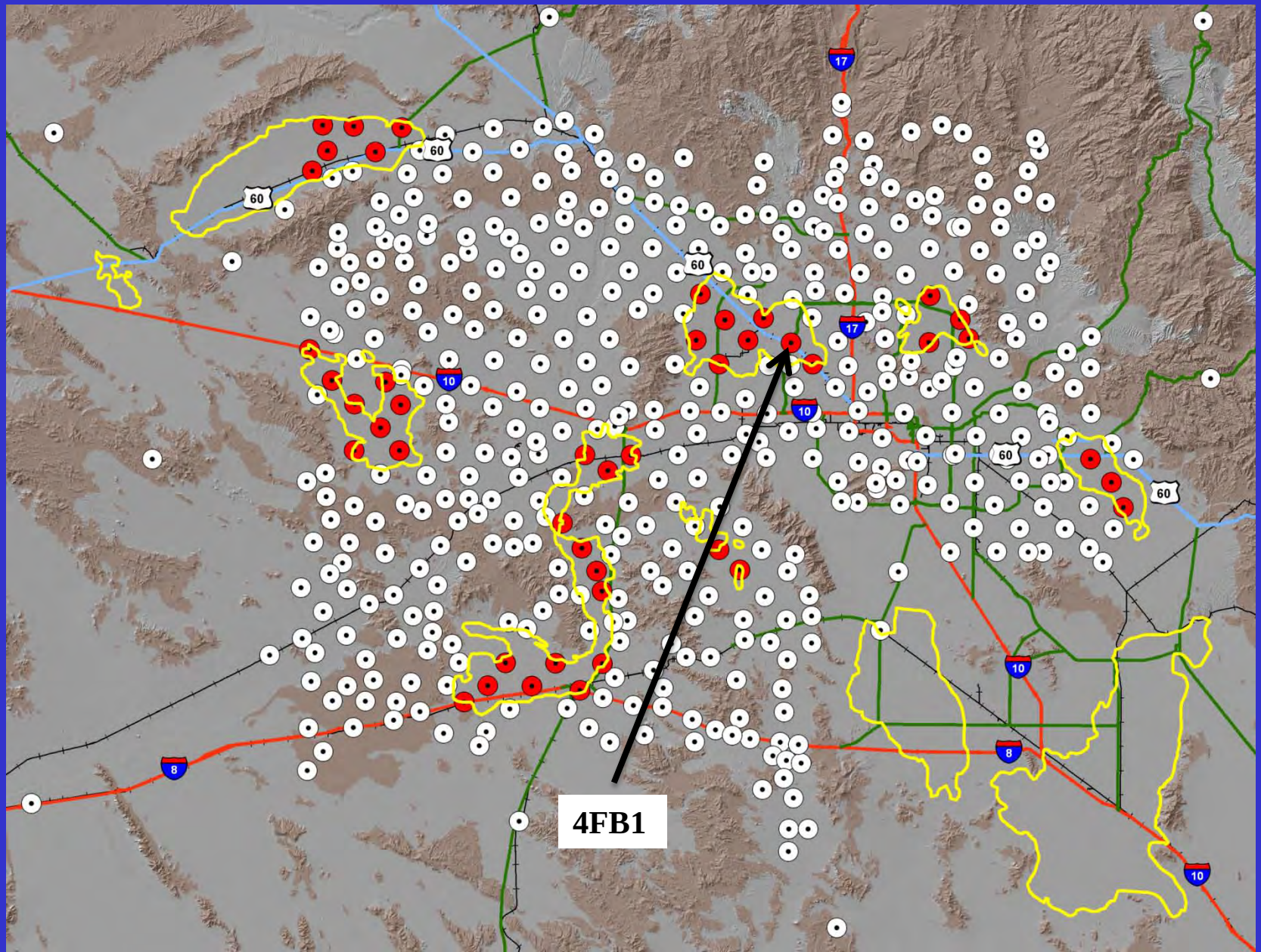
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Maricopa County Survey Control Affected By Land Subsidence (Red Dots)



Why A Surveyor Should Know Where Land Subsidence is Occurring?
Maricopa County Survey Control Affected By Land Subsidence (Red Dots)



Why A Surveyor Should Know Where Land Subsidence is Occurring?
Maricopa County Survey Control Affected By Land Subsidence (Red Dots)

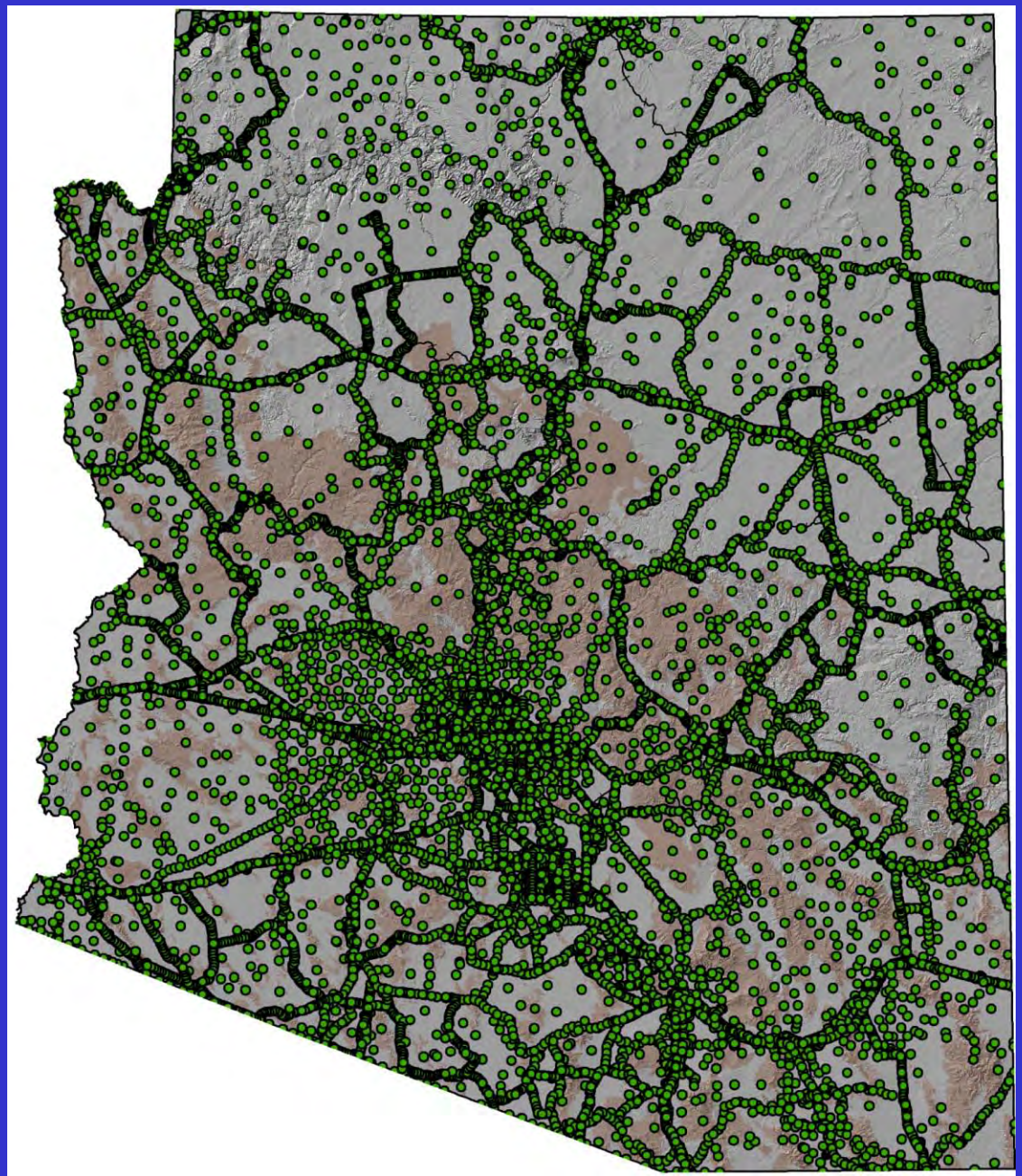


Why A Surveyor Should Know Where Land Subsidence is Occurring?
Maricopa County Survey Control Affected By Land Subsidence (Red Dots)

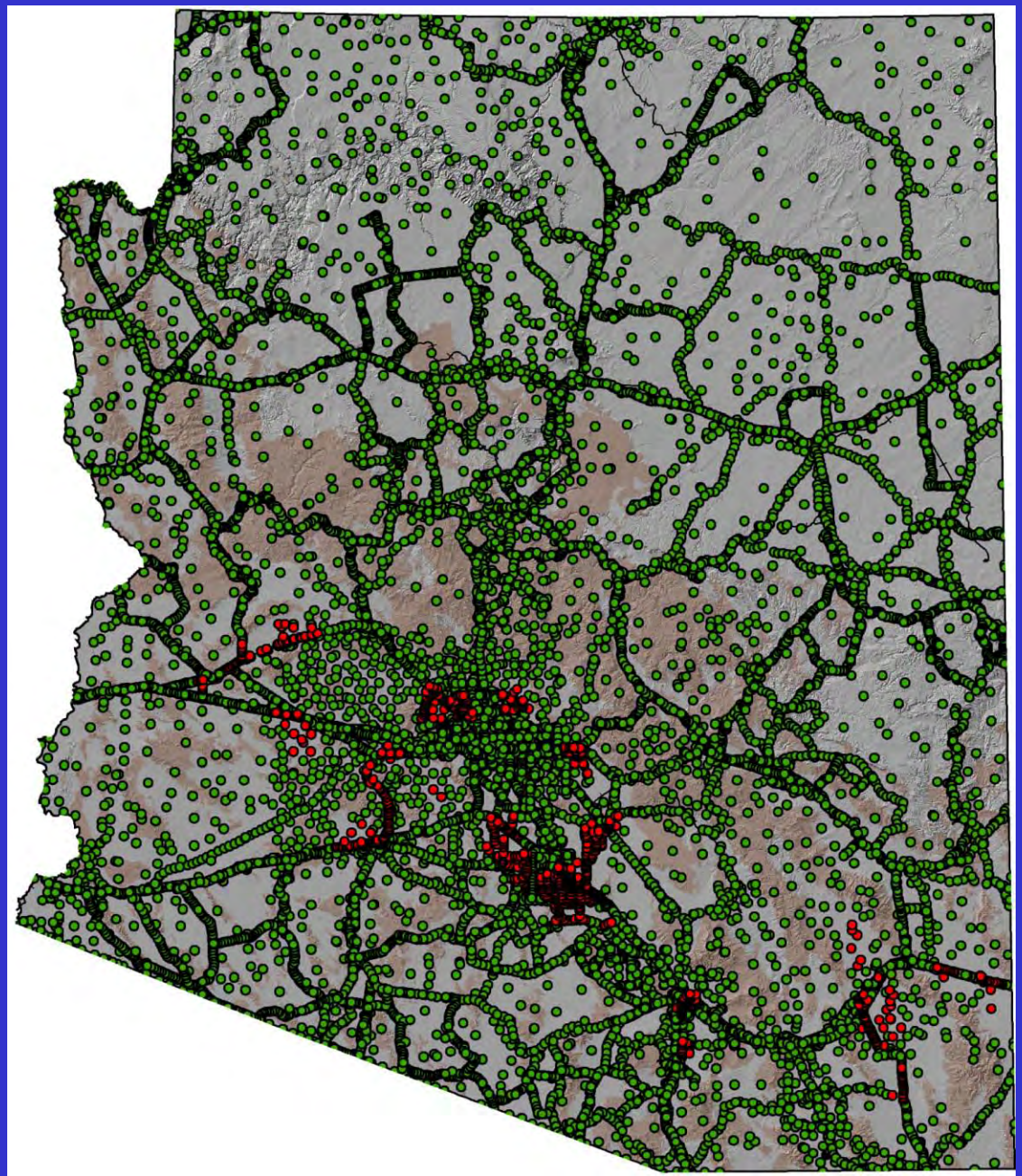
The NGS Data Sheet

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.82
1         National Geodetic Survey,   Retrieval Date = APRIL 16, 2010
 AJ3849 ***********************************************************************
 AJ3849  HT_MOD      -  This is a Height Modernization Survey Station.
 AJ3849  DESIGNATION -  4FB1
 AJ3849  PID         -  AJ3849
 AJ3849  STATE/COUNTY-  AZ/MARICOPA
 AJ3849  USGS QUAD   -  EL MIRAGE (1982)
 AJ3849
 AJ3849                        *CURRENT SURVEY CONTROL
 AJ3849
 AJ3849* NAD 83(2007)-  33 35 50.38588(N)     112 21 02.02338(W)      ADJUSTED
 AJ3849* NAVD 88     -       345.97   (meters)     1135.1     (feet)  GPS OBS
 AJ3849
 AJ3849  EPOCH DATE  -        2007.00
 AJ3849  X           -  -2,022,428.502 (meters)                       COMP
 AJ3849  Y           -  -4,918,821.679 (meters)                       COMP
 AJ3849  Z           -   3,509,505.916 (meters)                       COMP
 AJ3849  LAPLACE CORR-           0.69  (seconds)                      DEFLEC09
 AJ3849  ELLIP HEIGHT-         315.735 (meters)           (02/10/07) ADJUSTED
 AJ3849  GEOID HEIGHT-         -30.22  (meters)                       GEOID09
 AJ3849
 AJ3849  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
 AJ3849  Type    PID    Designation                        North    East  Ellip
 AJ3849  ----------------------------------------------------------------------
 AJ3849  NETWORK AJ3849 4FB1                                0.78    0.69   1.18
 AJ3849  ----------------------------------------------------------------------
 AJ3849
 AJ3849.The horizontal coordinates were established by GPS observations
 AJ3849.and adjusted by the National Geodetic Survey in February 2007.
 AJ3849
 AJ3849
 AJ3849                           STATION RECOVERY (2007)
 AJ3849
 AJ3849'RECOVERY NOTE BY MARICOPA CO DOT 2007 (BPD)
 AJ3849'FOUND THE MONUMENT IN GOOD CONDITION HOWEVER IT APPEARS IT IS
 AJ3849'SUBSIDING. WE PERFORMED FAST STATIC GPS AND IT SHOWS TO BE DOWN ABOUT
 AJ3849'0.30 FEET.
 AJ3849'
```

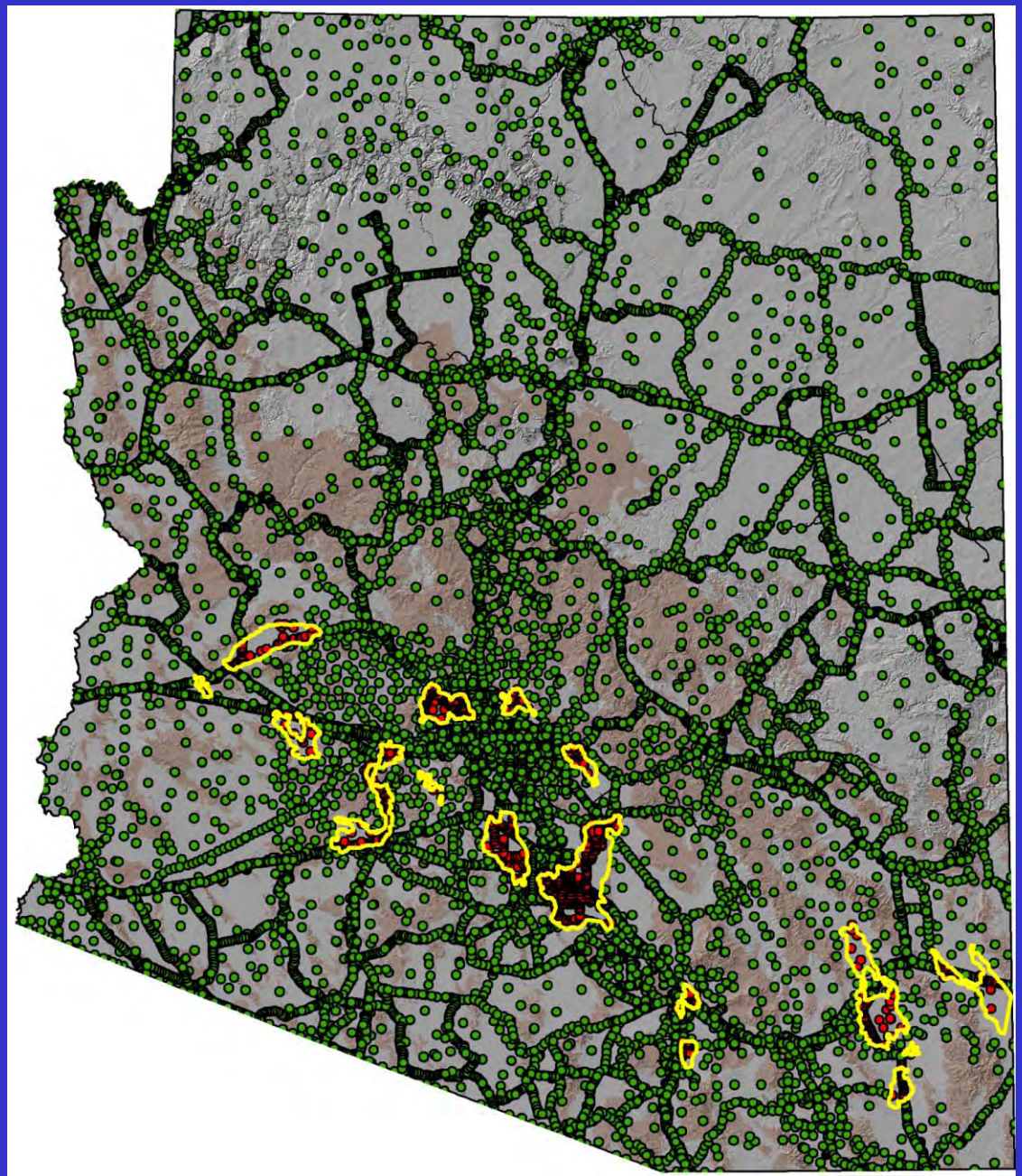
Why A Surveyor Should Know Where Land Subsidence is Occurring?
Arizona Survey Control According to the National Geodetic Survey (Green Dots)



Why A Surveyor Should Know Where Land Subsidence is Occurring?
Arizona Survey Control Affected By Land Subsidence (Red Dots)

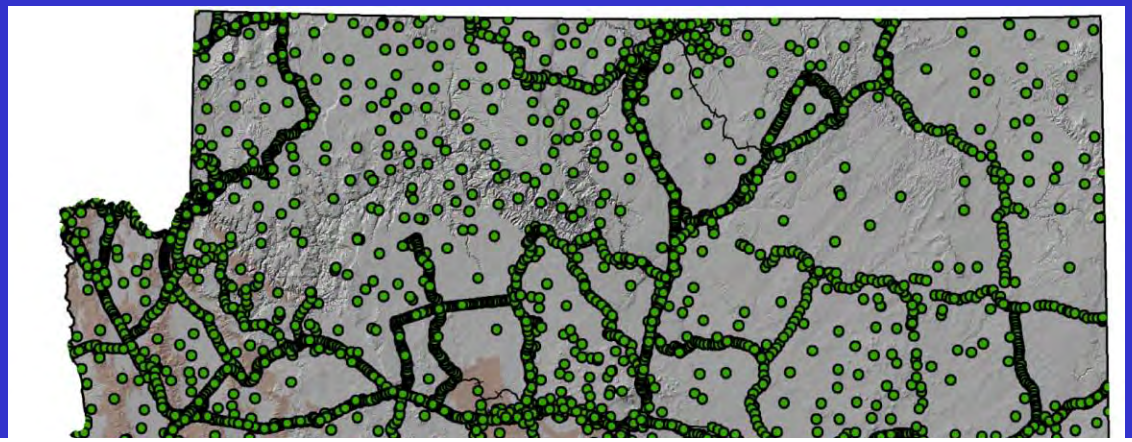


Why A Surveyor Should Know Where Land Subsidence is Occurring?
Arizona Survey Control Affected By Land Subsidence (Red Dots)

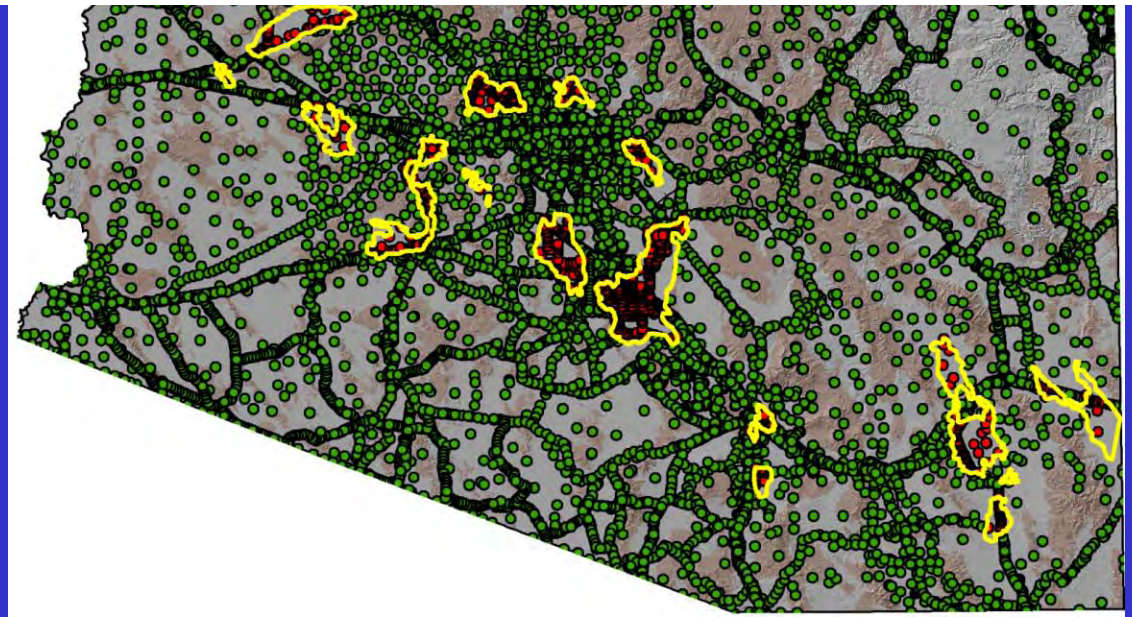


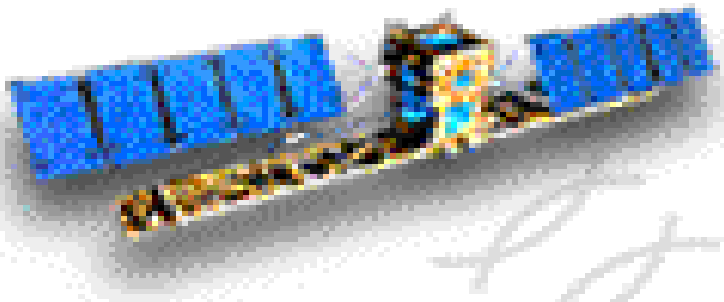
Why A Surveyor Should Know Where Land Subsidence is Occurring?

Arizona Survey Control Affected By Land Subsidence (Red Dots)



1,222 Survey Monuments Affected by Land Subsidence





Surveyed Elevations May Not Be Accurate

Old home elevations called into question

By Kyle Peveto The Beaumont Enterprise, Texas
Publication: The Beaumont Enterprise (Texas)
Date: Monday, February 16 2009

Feb. 16--Documents certifying the height of Southeast Texas properties above sea level may be as worthless as the homes flooded during Hurricane Ike.

Elevation certificates, needed for new construction permits in flood zones and flood insurance applications, are based on decades-old government monuments that some property surveying experts say are unreliable and have been corrupted.

Surveyors "have to depend on these things, and that's what happened in this case, where the monument was inspected in 1959 for the last time, and in 1980, when local surveyors used it, there had been 3 feet of subsidence," Gilley said. "But nobody knew that.”

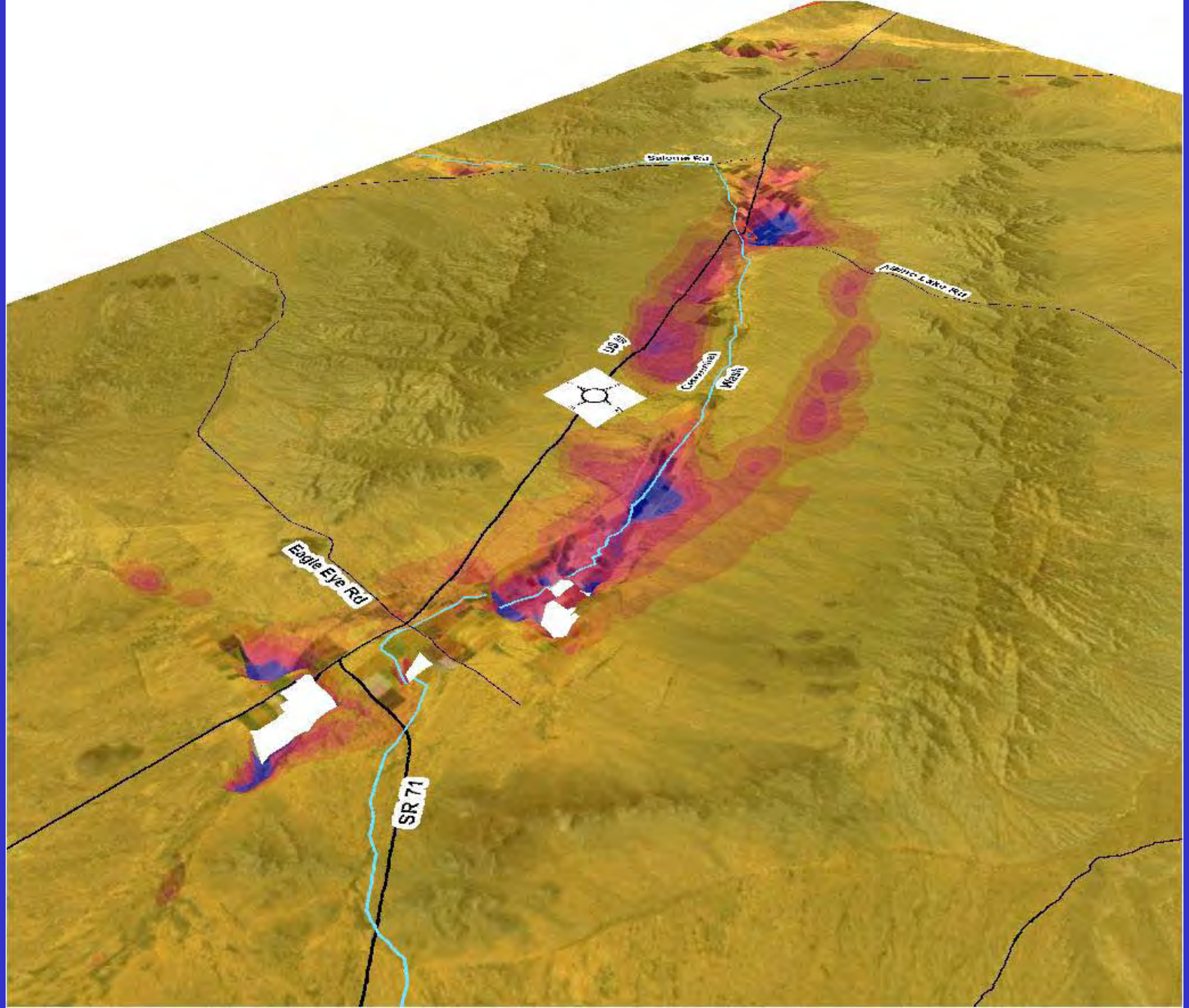
Floodplain Changed by Land Subsidence

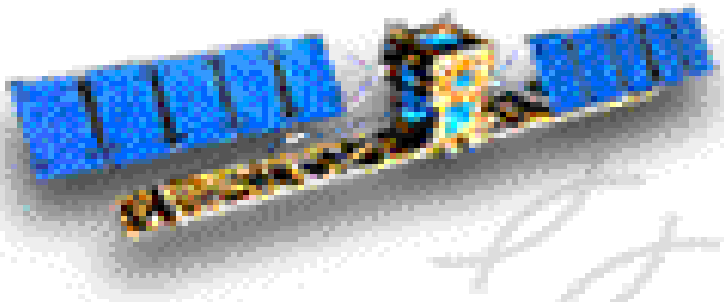
Floodplain Changed by Land Subsidence Centennial Wash in the McMullen Valley Maricopa and La Paz Counties


Town of Wenden Flooding January 2010
Photo Courtesy of La Paz County

Enhanced 3D View

Land Subsidence for the McMullen Valley


Eagle Eye Rd
SR 71
Welsh



Enhanced 3D View

Land Subsidence for the Town of Wenden

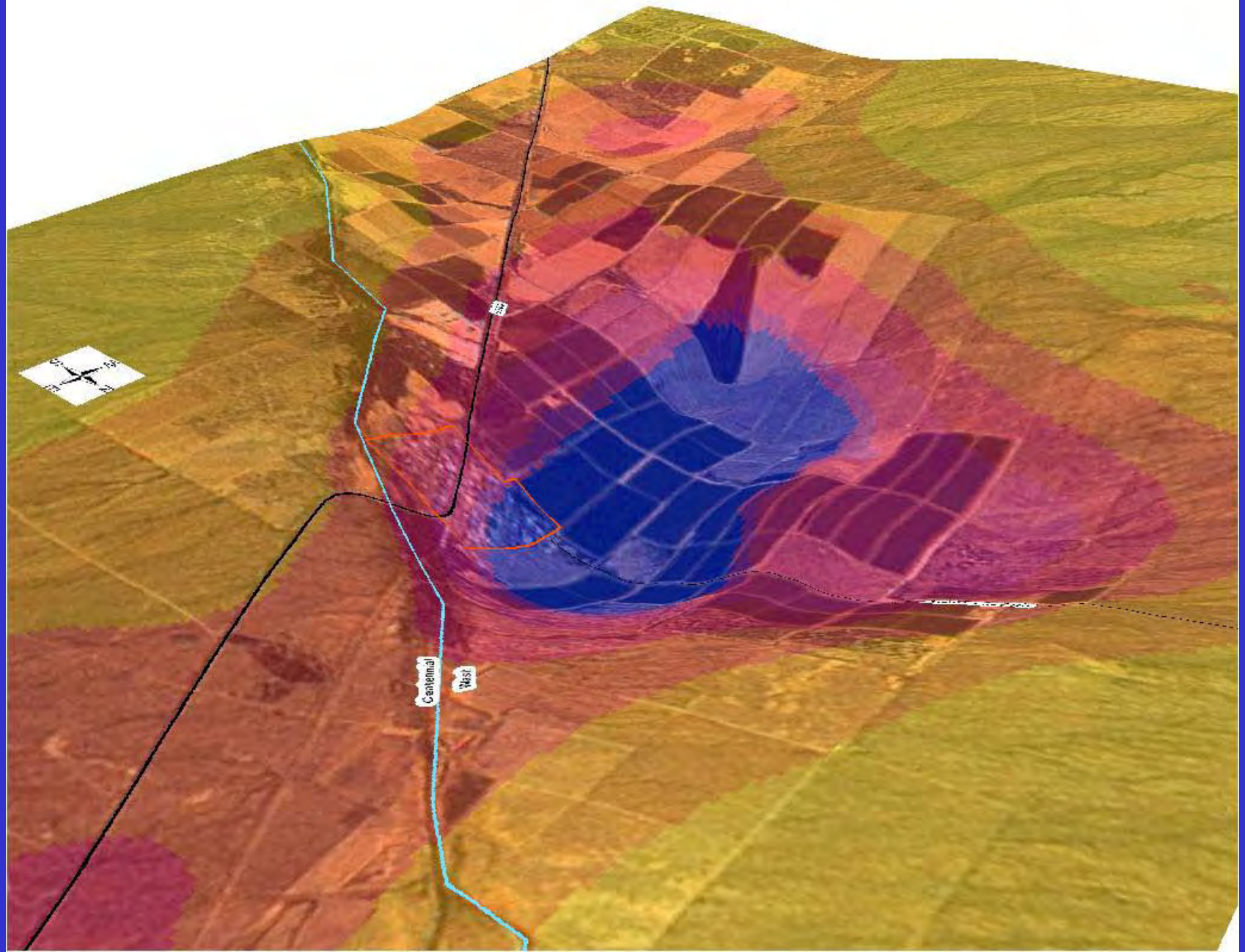

Centennial
West

Photo Courtesy of La Paz County

Photo Courtesy of La Paz County

Town of Wenden Virtual View Enhanced Land Subsidence
February 2009 to February 2010

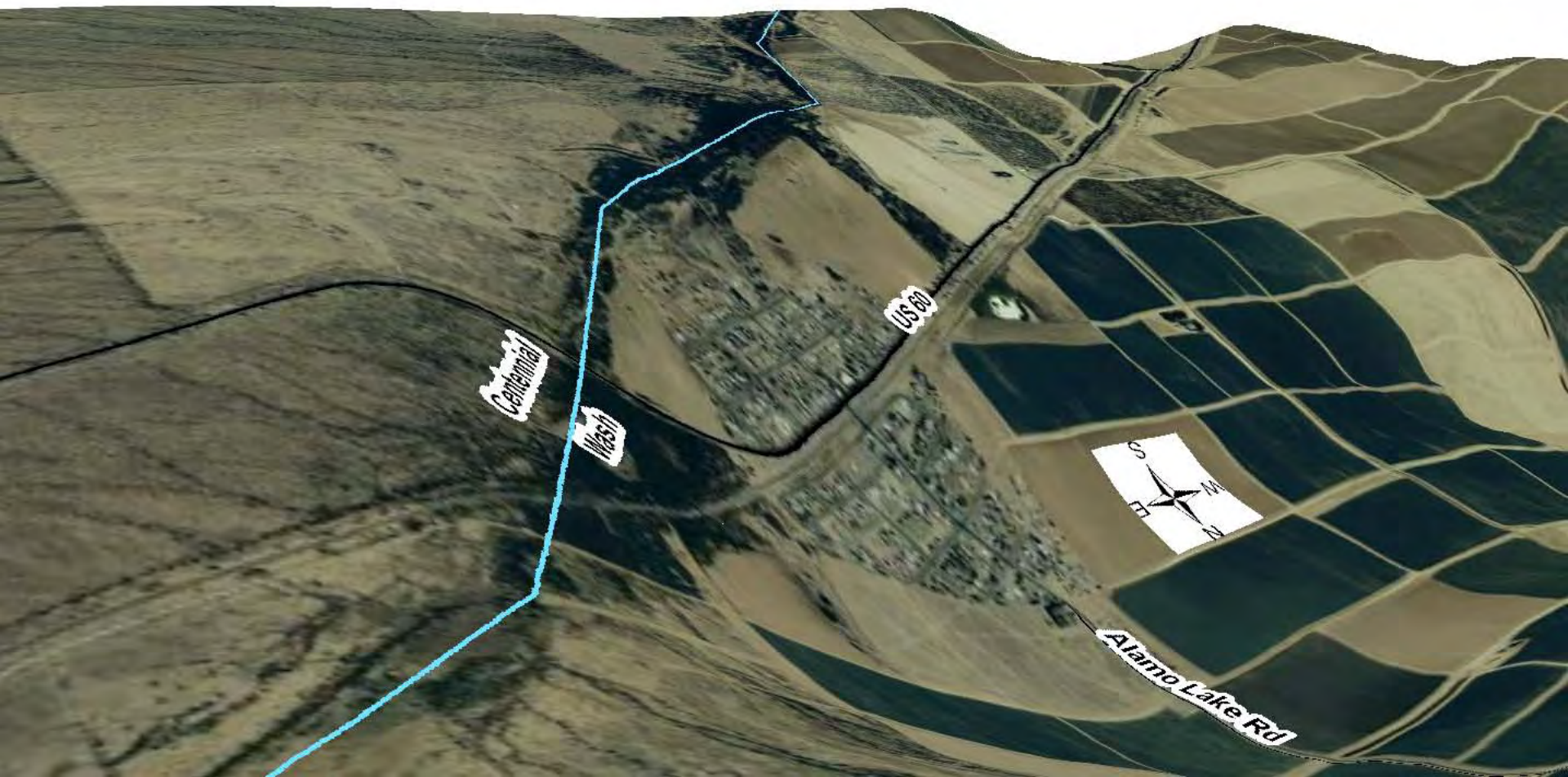
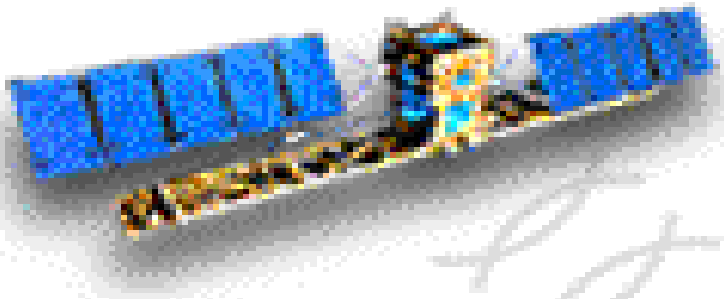
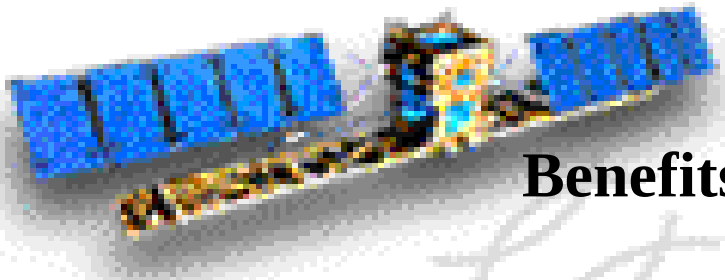


Photo Courtesy of La Paz County



Presentation Review



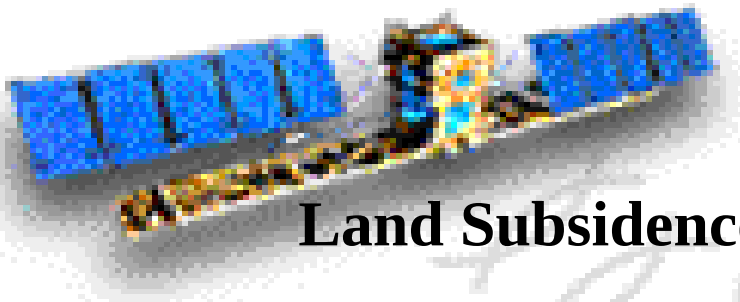
Benefits From InSAR

- Greatly improved land subsidence monitoring efforts across Arizona.

- Developed important partnerships with other State, County, and Local Agencies providing land subsidence data for their monitoring efforts.

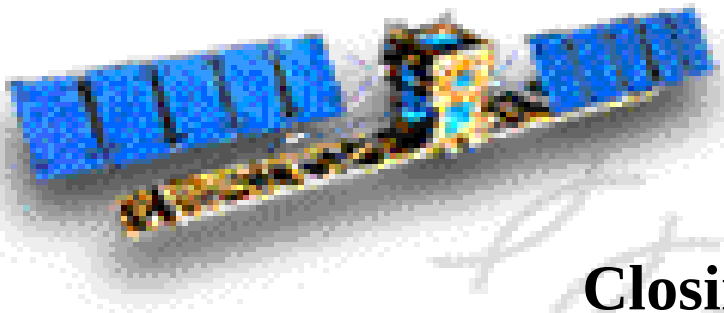
- Developed and published land subsidence maps for the State of Arizona.

- Greatly improved awareness of land subsidence and the potential problems caused by land subsidence.



Land Subsidence and InSAR Review

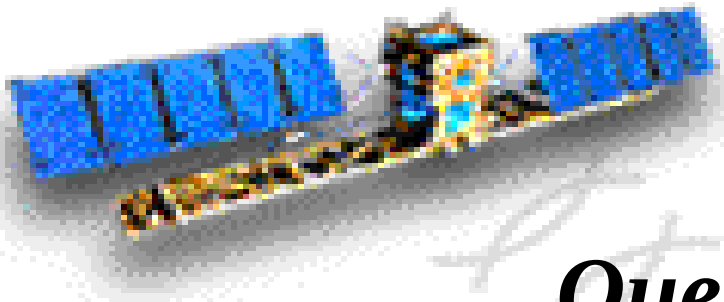
- Subsidence is a significant problem in the Southwestern U.S.
- Land subsidence should be monitored on an annual basis to monitor existing features and to detect new areas of land subsidence.
- InSAR is a valuable resource for monitoring land deformation, both subsidence and uplift.
- Various Federal, State, County, and Local Agencies use InSAR for land subsidence monitoring.



Closing Remarks

- You should now have a better understanding about land subsidence and how it can be monitored on a regional and local scale.

- Monitoring land subsidence using InSAR by hydrologist, geologists, surveyors, engineers, GIS professionals, floodplain managers, and scientists has increased dramatically over the past ten years.



Questions?

Brian D. Conway

Arizona Department of Water Resources

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Phoenix, AZ 85012

602.771.8500

bdconway@azwater.gov

ARIZONA
DEPARTMENT
OF WATER
RESOURCES